REPORT

OF THE

Proceedings of the Fourth Entomological Meeting

Held at Pusa on the 7th to 12th February 1921

Edited by

T. BAINBRIDGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist

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PREFACE.

THE following Report contains an account of the Proceedings of the Fourth Entomological Meeting, held at Pusa from 7th to 12th February 1921 and attended by over forty entomological workers from India and Ceylon.

Fifty-one papers on various aspects of Indian Entomology were read at the Meeting and of these fifty are included in this Report, the other not having been received for publication. The account of the discussion on the papers read at the meeting has been prepared from notes made by the Joint Secretaries, Messrs. R. Senior-White and G. R. Dutt.

That these Meetings are of very real utility and interest to all Entomological workers in India is best shown by the internal evidence of the Reports of the various Meetings which may be left to speak for themselves.

It may be added that no Report was published of the First Entomological Meeting, held in 1915, but that Reports of the Second (1917) and Third (1919) Meetings are still available.

T. BAINBRIDGE FLETCHER.

PUSA,
9th April 1921.

List of those who took part in the Fourth Entomological Meeting held at Pusa on 7th to 12th February 1921.

MEMBERS.

1. E. A. D'ABREU, F.Z.S., Curator, Central Museum, Nagpur.
2. E. A. ANDREWS, B.A., Entomologist, Indian Tea Association.
3. P. R. AWATI, B.A., D.I.C., Entomologist, Medical Research Fund.
4. E. BALLARD, B.A., F.E.S., Government Entomologist, Madras.
5. C. F. C. BEESON, M.A., F.E.S., Forest Zoologist, Dehra Dun.
6. B. B. BOSE, B.Sc., Entomological Assistant, Pusa.
7. M. CAMERON, R.N., F.E.S., Systematic Entomologist, Forest Research Institute, Dehra Dun.
8. Major S. R. CHRISTOPHERS, C.I.E., I.M.S., Central Research Institute, Kasauli.
9. M. N. DE, Sericulture Assistant, PUSA.
10. V. G. DESHPANDE, B.AG., Assistant Professor of Entomology, Poona.
11. DINA NATH, L.AG., Entomological Assistant, Punjab.
12. G. R. DUTT, B.A., (Joint Secretary), Personal Assistant to the Imperial Entomologist, Pusa.
13. H. L. DUTT, M.S.A., Officiating Economic Botanist, Bihar and Orissa.
14. T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., (Chairman), Imperial Entomologist, Pusa.
15. C. C. GHOSH, B.A., Assistant Entomologist, Burma.
16. F. H. GRAVELY, D.Sc., F.E.S., Superintendent, Madras Museum.
17. S. R. GUPTA, L.AG., Entomological Assistant, Assam.
18. ABDUL HAQ, Insectary Fieldman, Pusa.
19. M. AFZAL HUSAIN, M.A., Government Entomologist, Punjab.
20. J. C. HUTSON, PH.D., Government Entomologist, Ceylon.
21. C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S., Planter, Darbhanga.
22. M. O. T. IYENGAR, B.A., Entomologist, Bengal Malaria Research.
23. T. N. JHAVERI, L.AG., Entomological Assistant, Bombay.
24. J. L. KHARE, L.AG., F.E.S., Lecturer in Entomology, Nagpur.
25. Major FROILANO DE MELLO, Director, Bacteriological Laboratory, Goa.
26. C. S. MISRA, B.A., First Assistant to the Imperial Entomologist.
27. A. MUJTABA, Head Fieldman, Entomological Section, Pusa.
28. D. NOWROJI, B.A., Entomological Assistant, Pusa.

29. G. D. OJHA, Fieldman, Entomological Section, Pusa.
30. C. U. PATEL, Entomological Assistant, Baroda.
31. P. G. PATEL, Entomological Assistant, Pusa.
32. E. B. POULTON, D.Sc., F.R.S., Professor of Zoology, Oxford.
33. HEM SINGH PRUTHI, M.Sc., Assistant Professor of Entomology, Lyallpur.
34. Rao Sahib Y. RAMACHANDRA RAO, M.A., F.E.S., Assistant Entomologist, Madras.
35. B. C. SANTAPPA, Assistant Entomologist, Mysore.
36. RAM SARAN, Fieldman, Entomological Section, Pusa.
37. P. C. SEN, Entomological Assistant, Bengal.
38. S. K. SEN, B.Sc., Entomological Assistant, Pusa.
39. H. N. SHARMA, B.A., Entomological Assistant, Pusa.
40. DWARKA PRASAD SINGH, Fieldman, Entomological Section, Pusa.
41. T. V. SUBRAMANIAM, Assistant Entomologist, Mysore.
42. R. SENIOR-WHITE, F.E.S., (*Joint Secretary*), Entomologist (*Temporary*), Pusa.

VISITORS.

1. S. MILLIGAN, M.A., B.Sc., Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa.
2. Mrs. BAINBRIGGE FLETCHER.

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FOURTH ENTOMOLOGICAL MEETING, PUSA, 7th TO 12th FEBRUARY 1921.

Fourth Row: (*Standing*) Messrs. D. P. Singh, Sircar, Gupta, Ram Saran, Ojha, Santappa, Naoroji.
Third Row: (*Standing*) Messrs. Pruthi, P. C. Sen, Mujtaba, G. R. Dutt, S. K. Sen, Sharma, H. L. Dutt, Ramachandra Rao, Jhaveri, Iyer, Iyengar, Patel, Deshpande, Ghosh, Misza.
Second Row: (*Seated*) Messrs. Gravely, Husain, Beeson, White, Ballard, Cameron, Bainbrigge Fletcher, Christophers, Hutson, Inglis, De Mello, Andrews, Awati.
First Row: (*Seated*) Messrs. Bose, D'Abreu, Khare, Dina Nath, Mukerji, Narayanan.

PROCEEDINGS

OF THE

Fourth Entomological Meeting.

The Fourth Entomological Meeting was held at Pusa from the 7th to 12th February 1921, both days inclusive. The Proceedings were opened by Mr. S. Milligan, M.A., B.Sc., Agricultural Adviser to the Government of India, who gave an introductory speech as follows :—

INTRODUCTORY SPEECH BY THE AGRICULTURAL ADVISER.

Mr. Fletcher and Gentlemen :—Before opening the proceedings it is my melancholy duty to pay a tribute to the memory of a distinguished Entomologist who has been recently removed from our midst. I refer, of course, to the late Mr. F. M. Howlett whose untimely death has robbed us of a comrade and a friend, a man of unique personality whose place will never be completely filled.

Permit me in the first place, on behalf of the Members of this Institute, to extend to all our guests a hearty welcome to Pusa. I think that if any indication was required to show the value of these conferences, the attendance of upwards of fifty workers on Entomology from all over India would surely be sufficient. The success of your past meetings is due, I think, in the first place, to the fact that they are informal, in the second place that they are of a strictly technical nature; and, thirdly that they are not confined to members of a particular service or even to members of the services at all and that the common bond uniting all members is Entomology itself. From a professional standpoint, therefore, such meetings are ideal, and, as I have just stated, the proof of their value is to be seen in the large and representative gathering here assembled. I feel that I need not to an audience of this kind emphasize the importance of your branch of science. To the general public, insects are of importance chiefly from two points of view, *viz.*, the medical and the agricultural. It is well known that the carriers of some of the most dreaded of all diseases affecting man and the lower animals are insects and that a not inconsiderable portion of the crops which man grows for his own use is devoted to the upkeep of the insect world and pays its toll both before and after harvest. Now it is only natural that the ordinary

man should, in the first place, become more alarmed at the danger from disease carriers than from their vegetarian brethren, the former constituting a direct attack on his person, the latter threatening his food supply. Hence at the present moment the general public is probably more interested in what is called "medical" entomology than the agricultural branch of the subject. But, as time goes on and the human race increases in numbers and presses on the soil, it is evident that the proportion of crop which we can afford to give up to the insect world must be less and that in the end control of the vegetarian insects becomes also a question of race preservation. It is recognized by every one that insect control is a matter of the greatest difficulty. As a rule, the smaller the animal the more difficult it is to control (what is lost in size is, in fact, gained in elusiveness) and thus if any real control is to be established this can only be done by methods of great subtlety based on a very complete knowledge of the habits of the pests we are dealing with. The moral is I think plain. Gentlemen, you have a large programme in front of you and I will not detain you longer. I again wish you a successful conference and a pleasant stay at Pusa.

Mr. Milligan was followed by the Chairman, Mr. T. Bainbrigge Fletcher, Imperial Entomologist, who addressed the Meeting as follows :—

Opening Address by the Chairman.

Mr. Milligan and Gentlemen, In the first place I wish to thank Mr. Milligan on behalf of this Meeting for the kindly words which he has just addressed to us. It is no easy matter, as Mr. Milligan has had to do on this occasion, to address three meetings in one day on such diverse subjects as Mycology, Chemistry and Entomology.

It is once again my privilege to welcome to Pusa the various delegates who have come here to represent Local Governments and Departments at this Meeting, and on behalf of the Entomological Section of this Institute I offer you, gentlemen, a hearty welcome. Our only regret is that your stay here will be comparatively brief, as the business before us will not occupy more than this week. But whilst you are here I hope that you will realize that our resources are at your disposal and that any help or information which we can afford will be given to the best of our ability. The sessions of the Meeting will occupy our mornings but the afternoons will be free for you to consult our collections, records and library and we hope that you will take full advantage of doing so.

These Meetings, as I told you on the last occasion, are intended to be as informal as possible and are meant to provide a means for mutual help and discussion regarding all branches of Indian Entomology.

At our Second and Third Meetings I took the occasion to address you on various subjects and on this occasion I propose to speak to you regarding various happenings since we last met, next to place before you a few subjects of common interest, and then to make a few remarks upon the programme before us.

The last two years have been, I think I may say, years of steady progress in Indian Entomology. There has been no striking advance to chronicle but there has been a continuance of the solid work of laying foundations on which we shall be able to build later on. There has been expansion of the entomological staff employed by the creation in the Agricultural Department of the post of Government Entomologist in the Punjab and in the Forest Department of a post of Systematic Entomologist at Dehra Dun. The Zoological Survey has lost the services of Dr. Gravely but happily his transfer to the Madras Museum does not cause him to be lost to Indian Entomology. Amongst those who were present at former Meetings we shall miss the face of Mr. K. D. Shroff by resignation of his appointment, which is now held by Mr. Ghosh, transferred from Pusa. We are glad to see amongst us again Rao Sahib Y. Ramachandra Rao, whom we may well congratulate on his well-deserved honour, this being, I may add, the first occasion that a distinction has been conferred on any purely entomological worker in India.

The two years which have elapsed since our last Meeting have unfortunately taken their toll of the small body of workers on Indian Entomology, and we have to deplore the death of four of our fellow-workers.

Francis Milburn Howlett, Imperial Pathological Entomologist to the Government of India, died at Masuri on 20th August 1920 after a severe operation. Born in January 1877, he was the eldest son of the late F. J. Howlett, of Wymondham, Norfolk, and of Mrs. Howlett, now of Norwich. He was educated at Wymondham Grammar School and at Berkhampsted School, whence in 1896 he went to Christ's College, Cambridge, where he gained a scholarship. He left Cambridge in 1900 and was for some time on the staff of the Merchant Taylor's school. In 1905 he came out to India to Allahabad where he was Professor of Biology at the Muir College for about two years, and in November 1907 was transferred to the Indian Agricultural Service as Second Imperial Entomologist, a title subsequently changed to that of Imperial Pathological Entomologist, and in this capacity his work dealt with all insects carrying disease to men and other animals. From early youth Howlett had a strong taste for the study of insects, especially of Diptera, his first paper, published in the *Entomologists' Monthly Magazine* for 1907, dealing with the mating habits of *Empis borealis*. During the

earlier years of his service in India he was keenly interested in the collection and classification and life-histories of Indian Diptera and in 1908 he wrote the sections on Diptera and lice for Lefroy's *Indian Insect Life* (1909). But the visit to India of Mr. W. W. Froggatt, who showed that fruit-flies were attracted to the smell of certain oils, led Howlett's attention in the direction of tropic responses in insects, and he subsequently published papers on the influence of temperature on the biting of mosquitos and on the chemical reactions of fruit-flies. He also published several short papers on Sandflies. He was a good artist and several of his papers were illustrated by his own drawings. At the time of his death he had just completed a book on the control of insect pests. His name is commemorated in that of the tick, *Haemaphysalis howletti*, described by Warburton in 1913 from a hill pony at Rawalpindi, and in that of the *Empid* genus *Howlettia* described by Brunetti in his *Fauna* volume.

During his earlier years in India, Howlett suffered from ill-health and was absent on sick leave from 1909 to 1911 and again absent on leave for two years from 1915 to 1917; but latterly he seemed to have recovered his health, and his sudden death, at the comparatively early age of 43, was unexpected and to be regretted.

Charles A. Paiva was born of a respectable Anglo-Indian family at Purneah, on 30th May 1878. He was educated at St. Michæl's High School, Kurgi, and at St. Xavier's College, Calcutta, and joined the Indian Museum as a Gallery Assistant in July 1899. In January 1905 he was appointed Special Entomological Assistant, a post which he held, with several interruptions due to ill-health, up to the time of his death. For some years he had been threatened with phthisis but, notwithstanding a severe illness on more than one occasion, he devoted himself with enthusiasm to his work on insects and especially to the study of Indian Rhynchota, on which group he was already beginning to make a name for himself when he died suddenly on 11th August 1919. The various papers from his pen will be found in the *Records of the Indian Museum* and in the *Journal of the Asiatic Society of Bengal.*

The late Mr. J. L. Mitter after completing his course in the Veterinary College, Belgachia, Calcutta, joined the Veterinary Department, and prior to his coming to Pusa was holding the post of a Veterinary Assistant at Patna. He was subsequently appointed to one of the Entomological posts sanctioned to the late Mr. Howlett by the Indian Research Fund Association. After working in this Institute for about three years he went to Assam to assist Major Mackie, and subsequently his services were transferred to Kasauli where he came in touch with Major Christophers with whose help and guidance (to which he frequently

referred) he considerably enriched his knowledge of Medical Entomology. The papers published by him include notes on (1) the feeding habits of *Corizoneura* (*Pangonia*) *longirostris*, (2) the life history of *Haematobia* and (3) the breeding places of *Phlebotomus* in Lahore, the last paper being read before the Sixth Indian Science Congress held in Bombay. All these papers were published in the *Indian Journal of Medical Research*. He died during the latter part of 1919.

Lord Walsingham, who died in December 1919, never visited India but was keenly interested in the study of Indian Microlepidoptera and I understand that a very large number of specimens from India and especially from the Khasi Hills are contained in his magnificent collection which was presented by him to the British Museum (Natural History). In the earlier days of Entomology in India, several papers on Indian Entomology from his pen are to be found in *Indian Museum Notes* and he also wrote the portions on Microlepidoptera in Moore's *Lepidoptera of Ceylon* and Swinhoe's *Catalogue of the Heterocera in the Oxford Museum*. Many of our familiar insect pests, such as *Exelastis atomosa* and *Gracillaria theivora*, were first described by him, and his death, which terminated a long and useful career, came as a loss to us in India as to all workers on Microlepidoptera throughout the world.

It may be useful to indicate briefly what is being done in the case of the *Fauna* volumes on insects, so that you may be in a position to give special attention to the collection of specimens and information regarding those groups on which volumes are under preparation. In Coleoptera, volumes have been sanctioned by the Secretary of State on Carabidæ by Mr. H. E. Andrewes, on Meloidæ (better known to some of you as Cantharidæ) by Mr. K. G. Blair, a second volume on Curculionidæ by Dr. G. A. K. Marshall, and on Melolonthidæ by Mr. G. J. Arrow. The second part of Mr. Brunetti's work on Diptera Brachycera, comprising the Pipunculidæ, Syrphidæ, Conopidæ and Œstridæ, and completing this group, has also been sanctioned and will, I understand, be published shortly. A volume or volumes on Staphylinidæ will also be undertaken by Dr. M. Cameron but have not yet been authorized pending collection of further material. Other volumes which will probably be prepared comprise Culicidæ by Major S. R. Christophers and Mr. F. W. Edwards, Odonata by Major F. C. Fraser, Chrysomelidæ by Professor Maulik, Passalidæ by Dr. Gravely, and Muscidæ by Major Patton and Mr. Senior-White. You will notice that this list does not include several volumes which have been advertized as under preparation for several years past; of these, volumes III and IV on Butterflies, by Mr. H. H. Druce, Volume II of the Longicorn Beetles by Dr. C. J. Gahan, and the volume on Apterygota, Isoptera, and Embiadæ by Dr. Imms have all

been abandoned or deferred for the time being. The abandonment of the further volumes on Butterflies is especially regrettable as there is a decided want for these, but a curious fatality seems to pursue all works on Indian Butterflies, those commenced by de Niceville, Bingham and Moore all having been left uncompleted by their original authors.

The list of publications on Indian Entomology during the last two years is a very lengthy one and shows a decided tendency to increase in size every year. It is published annually in the *Report of the Board of Scientific Advice* and includes all the papers which come under my notice during each year. It seems hardly necessary to refer to the publications of the Agricultural and Forest Departments, of the Indian Museum, the Medical Research Fund and the Bombay Natural History Society, as you doubtless see all of these as they appear, but I may perhaps bring to your notice a few of the more important papers which have appeared dealing wholly or partly with Indian insects. Amongst these may be mentioned the papers on Coleoptera by Messieurs Lameere, Fleutiaux, Pic, Achard, Boucomont, Hustache, Desbordes and d'Orchymont in the publications of the Entomological Societies of France and Belgium, by Arrow on Lamellicornia and Endomychidæ, by Cameron on Staphylinidæ, by Andrewes on Carabidæ, and by Champion on Coleoptera generally; in Lepidoptera by Lord Rothschild on Sphingidæ, by Colonel Swinhoe on Noctuidæ, by Prout on Geometridæ, by Meyrick on Microlepidoptera, and by Hampson and Zerny on Pyralidæ; in Diptera by Townsend on Muscoid Flies and by various writers on Culicidæ; in Hymenoptera by Cockerell on Bees, Gahan and Girault on parasitic Hymenoptera, Dodd on Proctotrupidæ, Kohl on Crabroninæ and Sphecinæ, and Altson on the life history of *Nasonia brevicornis*, a blow-fly parasite which occurs in India, and also by Turner and Rohwer on several groups; in Coccidæ by Brain; in Thysanoptera by Bagnall; in Strepsiptera by Pierce; in Orthoptera by Bolivar on South Indian Acrididæ; in Isoptera by Imms in his study of *Archotermopsis*; on further fossil insects from Burmese amber by Cockerell; and on picturesque memories of insect-collecting in India by Rothney. Dr. G. C. Crampton's studies on the comparative anatomy and phylogeny of Insects, although not based on Indian species, have also very considerable general interest. Another paper, containing a good deal of information on Indian species, is Williams' Philippine Wasp Studies, published by the Hawaiian Sugar Planters' Experiment Station. Amongst separate publications dealing more especially with economic entomology I would call your attention to Dr. K. W. Dammerman's book on agricultural pests of the Dutch East Indies, to Heer S. Leefman's monograph on *Oryctes rhinoceros* in the Dutch East Indies, and to Dr. T. Shiraki's detailed description of

the Tabanidæ of Formosa. Captain Hingston's recently issued book, *A Naturalist in Himalaya*, also contains several interesting chapters on insects of the Hazara district.

Whilst on the subject of recent publications there are some sins of commission and omission to which I wish to draw your attention. In the former category may be included such items as misleading titles of publications. To give specific instances, I may refer to a paper by Hendel in *Annals of the National Hungarian Museum*, Vol. XIII (December 1915), which purports to describe Diptera from Formosa but (p. 448) contains the description of a new fly from Darjiling. A second example of the same sort of thing is instanced in a paper by Mr. Morley which appeared in the *Proceedings of the Zoological Society of London* for 1919 and which was entitled, "On Some Equatorial and other Species and Genera of African Ichneumoninæ contained in the collection of the British Museum"; in a paper with such a title one hardly expects to find two Indian species described as new. Such examples could be multiplied were it profitable to do so. The effect of the not infrequent use of such misleading titles is that one's work in trying to keep abreast of literature on Indian Insects is unnecessarily and unfairly increased, as in the course of every year one has to go over thousands of pages of literature merely to see whether it contains anything of interest to us in India not revealed by the titles of the various papers, and I think that we are entitled to protest against such a state of affairs.

Another point which I wish to bring to your notice concerns especially many of our Indian publications containing entomological papers and is with regard to the correct dating of such publications. The *Indian Journal of Medical Research* is a particularly flagrant offender in this respect; the part dated January 1920 did not come to hand until June, and the part dated April 1920 until November, whilst the parts which will presumably be dated July 1920, October 1920 and January 1921 have not come to hand yet. A part of the *Journal of the Bombay Natural History Society* bears on its cover the words "Date of Publication, 1st July 1920" but my copy did not reach me until 30th September 1920 and, as a member of the Committee of the Society, I receive an early distribution of the Journal, so that I cannot suppose that the actual date of publication was earlier than September. Bearing in mind the old saying about glass houses, I may add that our own publications have not been without sin in this respect; for example, Mr. Misra's Memoir on *Nephotettix* bears the date "May 1920" on the cover but was not actually published until 3rd August 1920. I am quite aware that most of these errors are due to delays in the press and that the misdating of such publications is due rather to ignorance of or carelessness regard-

ing the necessity of correctness in such a matter, but such incorrect dates of publication may lead to errors later on, and I think it desirable to call your attention to such cases now. The fact that a Journal bears a particular date on its cover is no proof that it was actually published at that time; the actual date of publication is the earliest date on which such a Journal is accessible to the public by purchase. I may add that in my annual list of publications on Indian Entomology the dates quoted against papers are the actual dates of publication so far as this can be ascertained.

No International Conference of Entomologists has been held since 1912 and I have heard of no proposals regarding the next Conference. An Imperial Entomological Conference attended by delegates from the self-governing Dominions and Colonies within the Empire, was, however, held in London in June 1920, and a report of this Conference is laid on the table for your information. I was selected to attend to represent India but, owing to the difficulty of obtaining a passage to England, I was unable to go and Mr. Beeson, who was then in England on leave, attended the meetings and will, I hope, give us some further account of it, the published report being disappointingly scanty. The main purpose of the Conference, if we may judge from the Resolutions passed, appears to have been to place the Imperial Bureau of Entomology on a more substantial financial foundation and to this end India has been asked to increase her annual contribution from £500 to £1,000 for the next five years, after which period the question of modifying the amount may again be raised.

No further general legislation regarding insect pests has taken place during the last two years. The regulations regarding the importation of plants into India have continued to be carried out by the Customs Staff at the specified Ports of Entry, but at Bombay, owing to complaints regarding treatment of plants during the process of disinfection, a local inspector has been appointed to assist in the fumigation of plant imports. The year 1919, however, saw the passing into law and into working of Madras Act III, which, to quote from its title, is an Act for the prevention of the spread of insect pests, plant diseases and noxious weeds. This Act has been applied in the Coimbatore district to control pests (principally *Platyedra gossypiella*) of Cambodia cotton and Mr. Ballard is, I hope, going to give us an interesting account of its practical working.

With regard to the Resolutions passed at our Third Meeting no action was required on Resolution I. Resolution II, dealing with the necessity for legislation concerning importation of bees and bee products has been rejected by Government for the time being. The whole question of the improvement of bee-keeping in India is a large one and I have put up

proposals for a bee-keeping expert, to be stationed at Shillong, to carry out experiments, to introduce improved methods and races of bees, and to train up a staff to carry these into effect, but no orders have yet been passed on this subject. When we have an expert in this line and have accumulated more information on the subject, we shall if necessary reopen the question of the necessity for legislation along these lines. From either aspect, the question is a difficult one and South Africa, where legislative restrictions regarding importation of bees and bees-wax have been rigidly enforced, has yet failed to keep out bee diseases. Resolution III, regarding the preparation of a general catalogue of all described Indian Insects, has been approved by Government and the Committee will meet and submit to you during this Meeting a report on the progress accomplished up to date. Resolutions IV and V, regarding an Indian Entomological Journal, required no action. Resolution VI concerned the adoption of a standard classification of entomological literature in India: I wrote to the Director of the Imperial Bureau of Entomology with reference to any classification which may be in use there and was informed that they have no standard classification other than a rough division of literature according to its country of origin: no orders have been passed on this Resolution as yet. Resolution VII, dealing with entomological education in Agricultural Colleges, has been circulated for the consideration of Local Governments. Resolution VIII, dealing with the part of entomology in nature study and school text-books, has been forwarded to the Education Department with an extract of the full proceedings. Resolution IX, which dealt with the question of organization of entomological work, has been dealt with by the Government of India, which is prepared to accept the proposal for an Indian Entomological Service with a Central Research Institute located at Coimbatore, and Local Governments have been addressed to see how such proposals meet with their requirements.

We are meeting here as a body of men more or less interested in the study of insects. Some of us are whole-time workers in this study, to others it is only part of their work, whilst others again find in Entomology a hobby. Some of us are interested in the economic aspect of the subject, as applied to agricultural or forest crops or to diseases of man or animals, others derive their main interest from a study of the habits or systematics or other aspect of Entomology, but we are all united in the study of insect life. In the case of those who do not share this interest there is sometimes found a sort of *cui bono* ? attitude towards Entomology and its votaries, an idea probably founded on the fact that insects are small animals and that, therefore forsooth, they are of small importance. We who deal with entomological questions know well that this is not the case

but probably few even of us have tried to realize what is the real importance of the study of Entomology in a country such as India, where seven-tenths of the people depend directly for their livelihood on the produce of their fields, which produce is ravaged by insect pests both before and after harvest and where such a vast aggregate toll is taken by insect-borne diseases both amongst man and his domestic animals. It is usually computed, by those who are in the best position to judge, that the annual damage to agricultural crops by insect pests is about ten per cent.; that is to say, the farmer who reaps what he considers to be a normal full crop actually gets only nine-tenths of what he would have got had there been no damage by insect pests. We have few exact records of damage, but in the case of main crops such as rice it is probable that an estimate of ten per cent. damage is a fair one. Wheat is rather an exception, although it is seriously damaged by termites in some districts, but as against this it is badly damaged in store after harvest. I have been at some trouble to collect figures of the annual average value of the outturn of agricultural crops in India and this comes to the total value of Rs. 1,682,42,73,000. Applying the ten per cent. rule to this we get an annual loss due to crop-pests of Rs. 18,693,63,666, or say Rs. 18,000,00,000 in round figures. I have taken no account of losses to stored grains, holding these as covered by the ten per cent. rule. Large as this loss is, it is only a part of the damage wrought by insect pests. We have roughly a quarter of a million square miles of forest in India, of which roughly a half is workable; I cannot give even a rough guess at the average amount of damage done annually by insect pests in Indian forests but we shall be well within the mark, I think, in placing it at an average of Rs. 100 per annum per square mile over the workable area, neglecting the unworkable areas altogether, and this figure gives us another Rs. 125,00,000 to add to our bill against the insect world. Then we have the various insects which carry disease to man and animals. I believe that somewhere about a million deaths per annum are estimated as due to malaria, without taking into account the incalculable loss to the wage-earning capacity of the people due to this disease. In the twenty years 1898-1918 a total of 10,254,221 people are returned as having died of plague, or an annual average of 512,711. Then we have other diseases such as Kala-azar and elephantiasis and a proportion of such diseases as cholera, so that we shall probably not be far wrong in estimating the annual death-roll from insect-borne diseases as approximately 1,600,000. It is difficult to put a money-value on this loss, but it must be remembered that the figures given are totals of all degrees in the population and that not all are wage-earners, so that we may estimate a modest value of Rs. 100 per life, which gives us a figure of Rs. 1,600,00,000.

Next we have the cattle, on which the whole cultivation of the country depends, and the total money-value of these animals may be estimated at Rs. 4,779,50,000; taking the losses in live-stock and animal labour or produce (hides, milk, flesh, [illegible], etc.), due to premature death, debility or damage caused by arachnids and insects at 8 per cent. of this total value, we find an annual loss under this head of Rs. 38,236,000. Totalling these various headings we find the losses due to :—

	Rs.
Crop-pests	1,80,00,00,000
Forest-pests	1,25,00,000
Human diseases	16,00,00,000
Animal diseases	3,82,36,000
TOTAL	2,01,07,36,000

or in all, say, in round figures two thousand millions (or two hundred crores) of Rupees every year. I do not think that these figures are at all exaggerated and it is needless to add that they disprove any idea that Entomology is a minor science of little practical importance. If we, by a study of insects and by practical application of the knowledge gained thereby, can save even one per cent. of this enormous wastage of the national wealth of India, such a saving would more than justify the most complete expansion of entomological work that we can possibly imagine.

When I last addressed you two years ago we met under the shadow of the Great War which had come to a close just before our Third Meeting and which for over four years had filled the newspapers with lengthy casualty lists and details of the great struggle. But we entomological workers are still living under the shadow of a Great War, a strife between the Insect World on the one side and Mankind and his possessions on the other, a Great War of Waste which is taking place every day not only in India but throughout the whole world and beside which the Great War of the Nations becomes almost insignificant when we reckon up the total losses on our side. Throughout the whole world mankind struggles to raise crops to provide food for his wants and in every country under the sun his crops are ravaged by insect-pests and he himself and his domestic animals stricken with diseases carried by insects. To us, as entomologists, such a statement is a truism, although, as I have already said, few even of us realize the magnitude of the losses caused by insects, and I am far from wishing to emulate the Bell-man by repeating :— "*I have said it thrice*" : "*What I tell you three times is true.*" However, as entomologists it behoves us to try to educate the General Public into some realization of the waste of national wealth due to insect pests and it is with this object in view that I have addressed you on this subject.

For the present Meeting we have a fairly full programme although it does not contain the titles of as many papers as were read at the last Meeting. The subjects of most of the papers now offered are sufficiently indicated by their titles and it is only necessary for me to refer to a few of them. Under Section I, which includes papers on Crop Pests, we do not propose to go again right through the whole list of insects known to damage crops in India, as that was done, according to crops attacked at our Second Meeting and according to the insects, arranged in systematic order, at our Third Meeting, and full accounts of both are on record. We shall therefore deal only with additions and corrections to the lists already published. Major Froilano de Mello is giving us a paper which includes the first entomological records from Portuguese India and we may hope that it will be only the first of a series of observations on insect pests of this part of India. T. V. Ramakrishna Ayyar is sending an Entomological Pest Calendar for the Madras Presidency and it is probable that some of you may be sufficiently interested and have enough information to enable you to construct similar calendars for other Provinces. Rao Sahib Y. Ramachandra Rao proposes to take us outside of India and to tell us something about the Insect Pests of Mesopotamia. Some of these will doubtless be familiar to us but the fauna of Mesopotamia should be palæarctic rather than oriental. A good deal of information has been published during the last few years on Mesopotamian insects and has included papers on Coleoptera by Holdhaus, on Odonata by Morton, on ants by Donisthospe and Crawley, on Tabanidæ and Muscidæ by Major Patton, on Anopheline mosquitos by Major Christophers, on a new termite by Silvestri and on insect pests of the date palm by Buxton.

In Section II (Forest Entomology) no papers have been offered this time but we hope that Mr. Beeson will give us some account of recent work in this line.

Section III, which comprises Medical and Veterinary Entomology, was omitted from our programme at the last Meeting but for the present one we have been promised several papers, mainly on mosquitos, amongst which I may mention that kindly promised by Major Christophers on the geographical distribution of Mosquitos in India. We have also a paper on Surra and Biting Flies, which will, I hope, elicit some discussion.

In Section IV (Household and Store Pests) we have only one paper to consider, on lethal temperature for some stored grain pests.

In Sections V (Bee-keeping) and VII (Silk) no papers have been offered, and in Section VI (Lac) there are two short papers, both by Mr. Misra.

Section VIII (Life histories and Bionomics) is responsible for about a dozen papers. We are again indebted to Professor Poulton for another

paper on the female forms of *Papilio polytes* and this will, I hope, inspire some of you to collect further material for the study of this subject. Another paper which I may refer to is one on protective movement and range of vision in Platypezid flies, which has been written up from notes left by Mr. F. M. Howlett.

Section IX deals with the Collection and Preservation of Specimens, under which heading Mr. Senior-White desires to bring before you certain points regarding damage to parcels of specimens in transit.

Section X (Systematic Entomology) contains two papers and under Section XI (Publications) we shall deal with the Progress Report to be submitted by the standing Catalogue Committee.

Section XII (Miscellaneous) is meant to provide for any subjects not included under other Sections, and under this heading we have included a paper, which has been prepared from material left by Mr. Howlett, on the practical application of Insect Psychology ; this will give an idea of the lines on which Mr. Howlett was working.

I.—ADDITIONS AND CORRECTIONS TO THE LIST OF INDIAN CROP-PESTS.

By T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist.*

The following are additions and corrections to the Annotated List of Indian Crop-pests published in the Proceedings of the Third Entomological Meeting.

HYMENOPTERA.

Camponotus maculatus infuscus, Forel.

(Page 33; before *Œcophylla*).

This was found at Pusa in November 1919 eating the shoots and tender leaves of brinjal.

Arge luteiventris, Cam.

Is the unidentified Tenthredinid (p. 38) found on rose at Shillong.

Arge fumipennis, Smith.

Is the unidentified Tenthredinid (p. 39) found on rose at Dehra Dun. We have it from Simla and Jeolikote also.

DIPTERA.

Chætodacus ferrugineus ferrugineus, Fb. (p. 41).

We have this also from Nagpur, from *Cephalandra indica*, 13th July 1912; from Sylhet, in ripe mango fruits; and also reared from apple fruits of uncertain origin but probably from Shillong.

Chætodacus ferrugineus incisus, Wlk. (p. 41).

We have this also from Nagpur, in lemon and grafted *ber* fruits; from Maymyo, in peach and mango; from Yercaud; and it was also bred from mango fruits purchased in the bazaar at Ootacamund (possibly from Salem).

Chætodacus zonatus, Saunders. (p. 42).

Also reared at Pusa from brinjal fruits and from custard-apple, and at Nagpur from mango fruits and grafted *ber* fruits. Also found at Taru, Peshawar, as late as [illegible]th October 1916.

Chætodacus maculipennis, Dol.

Bred from peaches at Pachmarhi at the end of May 1909.

Chætodacus diversus, Coq. (p. 43).

At Ahmedabad on 15th August 1917 this species was found strongly attracted to excrement of Tingidid bugs which had fallen on to leaves. At Pusa adult flies have been found attracted to ripe fallen fruits of *Eugenia jambolana*. It has also been found at Shillong (31st May 1918).

Chætodacus cucurbitæ, Coq. (p. 44).

Also bred at Nagpur from *Cephalandra indica* and at Mandalay from pumpkins. At Pusa the adult flies have been found attracted to ripe fallen fruits of *Eugenia jambolana*.

Chætodacus caudatus, Fb. (p. 44).

At Pusa this has been reared from pumpkin fruits, at Maymyo and Lashio from fruits of *Trichosanthes palmata* and at Pollibetta (Coorg) from a wild cucurbit.

LEPIDOPTERA.

Heliothis obsoleta, Fb. (p. 60).

All the entries regarding its occurrence on Safflower should be deleted.

Heliothis peltigera, Schiff.

This species occurs on Safflower and was confused with *H. obsoleta*. It has been reared on Safflower at Pusa, Coimbatore and Lyallpur, and also at Coimbatore on *Cajanus indicus* on one occasion.

Achæa janata, Linn. (=*Ophiusa melicerta*, Drury). (p. 80).

Also found feeding on crotons at Pusa in June 1920.

Euproctis flava. (p. 91).

Found at Lyallpur on apple in June 1917.

Oxyambulyx sericeipennis, Butl. (p. 96).

Specimens from Shillong have since been determined by Lord Rothschild as *O. substrigilis*, but seem referable rather to *sericeipennis* according to the key in the *Revision of the Sphingidæ*. The exact name of this species is therefore uncertain.

Elymnias caudata. (p. 105).

Found at Mercara (Coorg) on coconut and betel-nut palms, eating the leaves.

Stenachroia elongella, Hmpsn. (p. 117).

Also reared at Pusa from *bajra* heads and at Cuttack from *juar* heads.

COLEOPTERA.

Serica nilgiriensis, Sharp. (p. 166).

The larva also damages cinchona by feeding at the roots (see *Procgs. Third Entl. Meeting*, p. 1028).

Brahmina coriacea, Hope. (p. 167).

Also on apple leaves at Jeolikote in July 1915.

Hoplia flavomaculata, Moser (after *Apogonia*, p. 167).

This was found at Maymyo in May 1909, occurring in some numbers on peach.

Holotrichia longipennis, Bl.

This was sent in from Jeolikote in July 1912 and again in July 1915 as feeding in the adult state on the leaves of apple, apricot and plum.

Holotrichia rufoflava, Brsk.

This was found at Coimbatore, the larva at the root of orange trees, injuring the bark below ground-level (see *Proc. Third Entl. Meeting*, p. 1028).

Holotrichia repetita, Sharp (p. 168).

The larva damages roots of cinchona at Ootacamund (see *Proc. Third Entl. Meeting*, p. 1028).

Popillia maclellandi, Hope.

Common at Shillong from May to October, and is a minor pest in gardens, destroying rose flowers especially.

Popillia cyanea, Hope.

Common at Shillong in September and October. A minor pest in gardens, destroying *Canna* and other flowers. We have it also from Nongpoh, Darjiling and Mussuri.

Popillia chlorion, Newm. (p. 107).

The larva is a pest of cinchona roots at Dodabetta, Nilgiris (see *Proc. Third Entl. Meeting*, p. 1028).

Anomala rugosa, Arrow (before *A. varicolor*, p. 172).

This species is widely distributed along the Himalayas. It was found in small numbers feeding on apricot at Jeolikote in May 1915.

Adoretus horticola, Arrow (p. 176).

Also found at Jeolikote in May 1915 on grape and apricot.

Protaetia aurichalcea, Fb.

Found at Coimbatore on *cholam* and *Lantana* (see *Proc. Third Entl. Meeting*, p. 1028).

Pentodon bengalense, Arrow (p. 183).

Also from Hangu, in the Kurram valley.

Myllocerus lineaticollis, (Add on p. 192).

Found on mulberry in April 1920 at Natarhat, Ranchi district.

(*Unidentified Lamiad*) (p. 220).

This species, boring in orange shoots in Assam, has been named as *Monohammus versteegi*, already referred to on page 216.

Haplosonyx trifasciatus, Hope (add on p. 231).

This was found in May 1918 at Ramgarh, Kumaon, on tips of young apple shoots.

Wallacea sp. (p. 236).

This has been named as *W. dactyliferæ*, Maulik (F. I. Hisp., pp. 107-109, f. 34). It has also been recorded from Chingleput and Vaniambady, in Madras.

(*Unidentified Hispine*) (p. 236).

This species, found at Pusa on *Saccharum*, has been named as *Leptispa rufithorax*, Maulik (F. I. Hisp., pp. 78-79), described from the Nilgiris.

Phidodonta modesta, Weise (p. 238).

The specimens from sugarcane in Bihar and figured on plate 9 in *South Indian Insects* are not *P. modesta* but *Asamangulia cuspidata*, Maulik (F. I. Hisp., pp. 169-170, ff. 53, 54). *P. modesta* is recorded by Maulik (F. I. Hisp., pp. 163-164, f. 51) from Pusa and the Bellary district, but we have no examples from Pusa in our collection; it was originally described from Surat, where it occurs on sugarcane and *juar*.

RHYNCHOTA.

COCCIDÆ.

Icerya seychellarum, Westw. (p. 287).

Also on orange at Myitkyina, Upper Burma.

Phenacoccus iceryoides, Green. (p. 228).

Also on mango at Coimbatore.

Phenacoccus insolitus, Green. (p. 288).

Also on Cape gooseberry at Pusa.

Phenacoccus mangiferæ, Green. (p. 288).

Also on mango leaves at Coimbatore.

Pseudococcus lilacinus, Ckll. (*crotonis*, Green).

This has to be added to the List. It has already been recorded from Coimbatore by Mr. Ramakrishna Ayyar on pomegranate, destructive to the stalk and crown of the fruits. We also have it from Coimbatore on *Ailanthus excelsa* and from Sibpur (Calcutta) on *Achras sapota*.

Ripersia sacchari, Green. (p. 290).

Also on sugarcane at Poona.

Pulvinaria cellulosa, Green. (Add on p. 291).

This has been found on mango leaves and stems at Pusa.

Pulvinaria psidii, Mask. (p. 291).

Also on mango at Coimbatore.

Coccus hesperidum, Linn. (p. 293).

Also found on orange at Myitkyina, Upper Burma, and on mango at Surat, the latter record being noted by Mr. Green as a variety.

Eulecanium capreæ, Linn. (p. 294).

Also on peach and nectarine at Srinagar, Kashmir.

Saissetia (*Lecanium*) *nigra*, Nietn. (p. 295).

Also found on *Morus indica* at Poona and on mulberry stems at Myitkyina, Upper Burma..

Lecanium bicruciatum, Green. (Add on p. 295).

This has been found on mango at Coimbatore.

Lecanium discrepans, Green. (p. 295).

Also found on plantain at Gauhati.

Lecanium ramakrishnae, Green MS. (Add on p. 296).

Found on pear at Kulu.

Chionaspis dilatata, Green. (p. 296).

Also found on Mango leaves at Pusa.

Chionaspis centripetalis, Green MS. (Add on p. 296).

Found on apple leaves at Srinagar and on olive in Kashmir.

Chionaspis pusa, Green MS. (Add on p. 297).

Found on orange leaves and stems at Pusa.

Chionaspis vitis, Green. (p. 297).

Also found on mango at Coimbatore.

Aspidiotus destructor, Sign. (p. 300).

Also found at Pusa on *Eugenia jambolana*, and on leaves of *Cocos nucifera* at Chaumahani (Bengal).

Aspidiotus dictyospermi, Morg. (p. 301).

Also found on mango at Coimbatore.

Aspidiotus perniciosus, Comst. (Add on p. 302).

This is probably the most important addition to our list and has been found on pear at Kulu. Mr. Green, who has determined the material, notes that "the material examined showed signs of having been kept in check by predaceous enemies and internal parasites. Possibly the original home of the species may be in the Indian region, where it appears to have efficient checks." We may hope that this is so.

Chrysomphalus aurantii, Mask. (p. 302).

Also found on mulberry leaves and stems at Pusa. Mr. Green notes that the specimens found on pomelo at Myitkyina were attacked by a parasitic fungus.

Parlatoria blanchardi, Targ. (Add on p. 304).

Found on date palms at Lyallpur.

Parlatoria pergandii, Comst. (p. 304).

Also found at Pusa on *bael* (*Aegle marmelos*) and at Taru (Peshawar) on olive-trees imported from Spain. As it is already known to occur in India it is doubtful whether it was imported with the olive-trees.

2.—ADDITIONS AND CORRECTIONS TO THE LIST OF CROP-PESTS IN SOUTH INDIA.

(Plate I).

By E. Ballard, B.A., F.E.S., *Government Entomologist, Madras.*

Diptera.

P. 39. Anthomyiadæ. Cholam, Cumbu and Tomato flies.

I sent these three species to the Imperial Bureau of Entomology for identification in 1914 and 1915. They were all three identified by Mr. Grimshaw as a species of *Atherigona*. I did not agree with this identification as I know the flies to differ in habits, larvæ and structure. Dr. Marshall took the flies to Major Austin on his return from military service and he says that all three species are distinct and probably new. He has not yet had time to describe them. I might mention in passing that the "Tomato fly" is common in cotton fields badly infested by *Earias* sp. and can be bred from shoots bored by these insects. I have recently bred an Anthomyiad from Paddy which appears to be the same as the *cumbu* fly. This is, I think, the first time these flies have been recorded from paddy in South India but I am not quite certain of this. I have not had time to take up the study of these flies again since my return to India. They are however worthy of study as *cholam* and *cumbu* suffer from them to a considerable extent. The larvæ show interesting differences in the structure of the pharyngeal skeleton. The *cholam* stem fly is parasitized by *Tetrastichus nyemitawas*, Rohwer [*Ann. Mag. Nat. Hist.* No. 37, Vol. 7 (1921), pp. 131-132].

P. 49. Pachydiplosis oryzæ, Wood-Mason.

With reference to the remark that this fly is attracted to light I am inclined to believe that it is heat, not light, which causes the attraction. At one time while studying *Schoenobius bipunctifer*, we had in the Farm wet lands at Coimbatore, a big 200 candle power lamp on top of which was a black shade, designed to reflect light downwards. Very large numbers of *P. oryzæ* were found on top of the shade, fewer in the pan below the light. I noticed the same thing in my bungalow where a number of Cecidomyiads were always found at one time on top of a dark purple shade which was on the standing lamp.

P. 50. Cumbu and Cholam Cecidomyiads.

Contarinia andropoginis, parasitized by *Tetrastichus coimbatorensis*, Rohwer, has not been noticed since my return, nor have I seen *Itonida seminis* on *cumbu*. I have a note on the habits of *C. andropoginis* at the end of Prof. Felt's paper. (Plate I.)

Lepidoptera.

P. 60. Heliothis obsoleta was quite a bad pest of cotton last year (1920) on the Central Farm. I have a note on the fact in the Agricultural Journal. It is not so far in pest conditions this year but I have seen one or two larvæ eating cotton bolls and there was a brood early in December on *Corchorus olitorius*, L. It is late in attacking the second crop of Bengal gram this year; usually it is a very serious pest of this crop.

P. 65. Cirphis albistigma; not reported in 1920.

P. 70. Laphygma exigua entirely destroyed a field of Linseed on the Central Farm in 1919. The swarm swept through the field with astonishing rapidity. I noticed many being killed by large black ants (*Camponotus*).

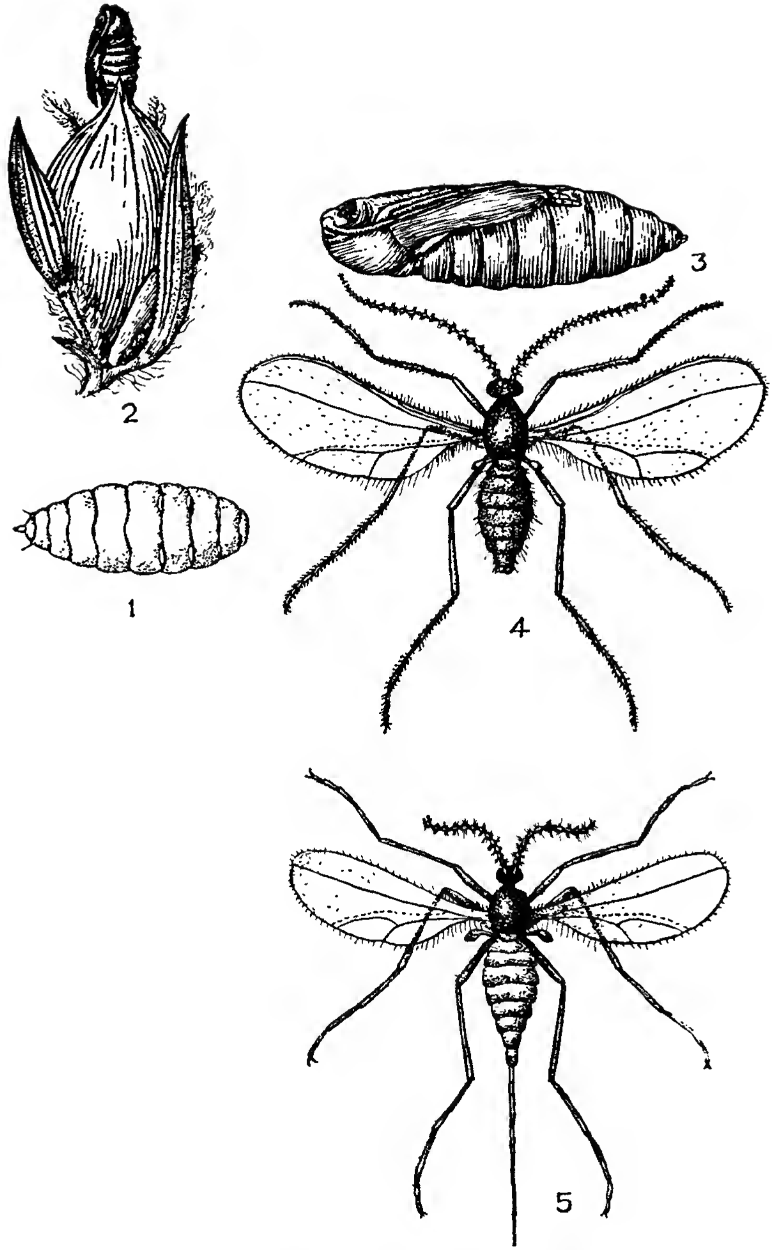
P. 79. Earias fabia and *insulana* are much less serious this year than last. It makes its appearance with great regularity about 15th October. As far as my experience goes it does not attack shoots when bolls are to be had. It is especially fond of *Abutilon graveolens*.

P. 81. Achœa janata is chiefly a pest in November and December. There were two broods of this insect at Coimbatore at this time in 1919. I am doubtful of the efficacy of hand-picking which was resorted to on the farm and found to be both slow and expensive. I think dusting has possibilities but it is doubtful how far the *raiyat* is to be trusted with stomach-poisons.

Chilo simplex. The eggs are parasitized by *Tetrastichus ayyari*, Rohwer.

P. 121. Schœnobius bipunctifer. T. V. Ramakrishna Ayyar noted it in large numbers all over the foot bridge of Shoranur station in Malabar, attracted to the light and laying eggs on the bridge. The night was wet.

I have an experimental area of about 120 acres at Podalada in Kistna district in the Godavari delta. We have been working there since January 1920. The scheme followed is to select all seedlings showing dead-hearts at the time of transplantation. These seedlings are rejected and destroyed. The general attack of *Schœnobius* in the delta has been very low. This year about 4 per cent. of dead-hearts



Contarinia andropoginis, **Felt.**

1. Larva, magnified ; 2, Pupa case projecting from attacked grain (×5) ; 3, Pupa, side-view (×16) ; 4, Male Fly (×13) ; 5, Female Fly (×13).

was the highest figure obtained in the non-experimental area. In the experimental fields the average was 2 per cent. We are studying the broods of *Schœnobius* throughout the year. I do not wish to say more at present as our work is really just beginning but records of males and females and of spent and gravid moths attracted to a light are kept, the time when moths are flying most freely, etc. The selection of attacked seedlings is quite easy once boys have been trained, and they can be trained quickly; the cost is about Rs. 2 an acre. I am not at all convinced that light-traps are or ever will be of much use. It also occurred to me that, even supposing that a number of moths are caught, all those who are not or who lay before coming to light, transmit, or might transmit their slight negative phototropism to their offspring so that in time a light-trap-proof brood will be evolved. Such an eventuality is, I think, possible. While I do not doubt the total loss caused by *Schœnobius* I am doubtful about the loss caused to the individual *raiyat*. I am of the opinion that the magnitude of *Schœnobius* attack in any given year is much exaggerated. I was once informed by a Farm Manager that the loss due to *Schænobius* on the farm wet lands was 25 per cent.; actual counts showed 0·4 per cent. to 0·7 per cent.

P. 126. Nymphula depunctalis. A serious pest of paddy in the second crop in Malabar. Complaints are universal about this insect in South Malabar. It was, I think, sometimes confused with *Cnaphalocrocis* but I am doubtful about this.

P. 127. Cnaphalocrocis medinalis. From what I have seen in Malabar and South Kanara I think this insect does more damage than is generally realized.

P. 138. Clania crameri (?), I am told, is a serious pest of Tea in the Anamalai Hills.

P. 149. Anatrachyntis simplex, (*Pyroderces coriacella*). I have no evidence that it is a pest. Everything points to its being purely a scavenger.

P. 157. Nephantis serinopa; parasitized by *Elasmus nephantidis*, Rohwer.

COLEOPTERA.

P. 185.	*Xyleborus biporus*	Rubber. All from Mooply valley.
	,, *noxius*	
	,, *perforans*	
	,, *compactus.*	Robusta Coffee. But did not attack Arabica on same estate.

Xyleborus biporus appears to attack healthy trees, but I have not had time to visit the estate to confirm this.

P. 198. *Apion* sp. On jute and *Cajanus*.

It might interest you to know that there was in Central Africa an *Apion armipes* which attacked cotton in the same way as *Pempheres affinis* does in this country.

P. 202. *Pempheres affinis*. Work now being done at Coimbatore. Distribution seems fairly even in cotton-growing tracts, but I did not see it at Anakapalle. It was found in stems from Bellary district, but the characteristic swellings were not to be seen. This may account for its being overlooked. Also the fact that it attacks below the ground in country cottons. It breeds freely in *Corchorus olitorius* (not a malvaceous plant, but belonging to the next family, Tiliaceæ), in two species of *Abutilon*, in *Hibiscus rosasinensis* and *H. esculentus* (Bhindi), *Gogu* or Deccan hemp, and, when all cotton was off the ground, was found on *Ficus religiosa* in the Botanical gardens at Coimbatore. It was not bred from this tree but couples were copulating freely on the tree. Attempts are being made to ascertain whether a resistant strain of cotton can be grown. We are going into the lifehistory of this insect very thoroughly but I do not wish to say much about it at present. A parasitic grub has been found on the larva of *Pempheres affinis* but could not be reared. Specimens of *Pempheres* have been found killed by a fungus. It attacks both larva and adult. With reference to remarks made at the last Conference and about pulling out all first-attacked plants, I wish to say that although all Coimbatore district pulled up its cotton by the end of August 1919 and 1920, there has so far been no appreciable result as regards *Pempheres* attack ; 75 to 100 per cent. of the plants are attacked by the end of the season, and there is no evidence to show that the continuous pulling up of the plants on the Farm has had any effect in lessening the attack of the Pest. Cotton grown for the first time in the Wet Lands 800 to 1,000 yards from the nearest cotton was attacked quite heavily in 1919. Two or three years of the Pest Act might possibly have some effect. Country cottons are more resistant than Cambodia and Bourbon. Cambodia-Bourbon cross appears to be more resistant than Cambodia but, as all our investigations are in their infancy, I do not wish to say more, as too many statements have been made about *Pempheres* and other insect pests on insufficient *data*. Nothing is known as to the effect on the plant. As a general rule only seedlings and young plants are killed by the *Pempheres* attack. It is rare to find full-grown plants killed although there may be multiple infestation. I am not convinced that *Pempheres* is as serious a pest as is made out.

P. 212. Batocera rubus. This was sent to me and reported to be attacking rubber in the Meoply valley in 1920. Only one or two trees were attacked.

P. 235. Leptispa pygmæa. Not much is known about it. As far as I know at present it is more localised than *Hispa.*

P. 237. Hispa armigera. This is a serious pest of all three crops of paddy in South Kanara. In response to appeals from the Acting Collector, I arranged for a demonstration in spraying as a control for this pest. Crude oil emulsion was used and certainly acted as a deterrent and where seed beds were taken in time was successful. However I do not think it is a very practicable proposition even if worked through co-operative societies. Bagging and clipping are equally efficacious. Great success was obtained in one field which it was possible to flood by running in water with crude oil emulsion floating on it. This might be a useful control for the first crop. But a great deal of study is needed of this insect and our control methods are merely stop-gaps, like the majority of the so-called remedies for crop pests.

To my mind *Hispa* is famous for the fact that, as far as I am aware, it is the only insect which has been mentioned by name in the weekly reports of the Collector of a District to Government. I am not sure that it was not mentioned in the Government of India's report to the Secretary of State.

Hispa armigera does not seem to be a serious pest in Malabar. Further experience may show otherwise.

P. 242. Gnathospastoides rouxi, Cast. An interesting method of control is used in Bellary. Assafœtida is mixed with cow-dung. In this beetles which have been caught are rolled and then liberated. *Raiyats* claim that they drive other beetles out of the fields !!

P. 244. Elateridæ. Elaterid grubs were found eating paddy seedling roots in Kistna district. The adults were not reared.

P. 244. Sphenoptera gossypii. The Deputy Director of Agriculture, III Circle, tells me that in the Ceded Districts *S. gossypii* is a serious pest of cotton.

RHYNCHOTA.

P. 257. Leptocorisa varicornis. Rotting flesh was tried without success at Coimbatore as a bait. Bagging is quite successful and kept them under control on the Central Farm this year. This might be due to early ripening of some varieties of paddy in which the bugs congregated and on which they were caught.

From the train I saw a *raiyat* in Malabar clearing the fields with a hand net (bag) which seemed to be made on our model.

P. 262. Dysdercus cingulatus appears to vary very much in its occurrence. I think it worthy of more extended study. On the Central Farm at Coimbatore I should not call it a pest. It is almost a rarity.

P. 261. Oxycarenus lætus is an insect the study of which should be taken up in the near future.

P. 265. Helopeltis antonii, Sign. I am certain that this insect is the cause direct or indirect of the withering of *nim* shoots for it can be controlled by spraying and withering prevented or arrested. I suspect bacteria to be the real cause of the withering, the bacteria being injected by *H. antonii* while feeding. This is simply a theory but would account for the fact that the number of withered shoots seems to be so much out of proportion to the number of insects found. This insect will shortly be studied in collaboration with the Government Agricultural Bacteriologist.

Platyedra gossypiella, Saunders. A good deal of work on this insect is being done at Coimbatore; in fact, I am making every effort to concentrate on it. The Pest Act reduced the attack in the season and summer-pickings considerably. The preliminary results of our investigation have been sent for publication. One interesting fact which has come out is that there appears to be a long feeding stage in the season-picking, that is, between January and the end of March. After that time generations overlap with rapidity. The three nearest approaches to a long-cycle larva which we have found came from season-picking, *i.e.*, during the hot weather. We have not been able to do our investigations on as large a scale as I should wish owing to a variety of reasons which need not be discussed here, and to the present system under which a Provincial Entomologist has to work, which, as every one knows, makes any really thorough investigation an impossibility. I hope that at the next Conference I shall have something more definite to say on the subject. I have not found *Platyedra* breeding in *Thespesia* as it is supposed to do, but it breeds freely in *Bhindi*. When the attack is severe, as in 1919, country cottons suffer but so far appear to be 20 per cent less attacked than Cambodia. They have been alleged to be immune but I have so far not found this to be the case nor is at all likely to be true.

In spite of the excellent work done in Egypt a very great deal more is required in India on this pest which is of major importance.

ORTHOPTERA.

Grasshoppers caught at poison baits on the grounds of the Forest College, Coimbatore, included the following species :—

1. *Orthacris acuticeps*, Bol. A troublesome pest of gardens.
2. *Acrida brevicollis*.
3. *Aiolopus affinis*, Bol.
4. *Acrotylus humbertiana*.
5. *Catantops indicus*. A fair number of these.
6. *Chrotogonus saussurei*. A very common pest.
7. *Cyrtacanthacris ranacea*.

At Gobichettypalayam, Coimbatore district, the following were damaging paddy nurseries in 1915 (?) :—

1. *Gastrimargus marmoratus*.
2. *Atractomorpha crenulata*.
3. *Acrotylus humbertiana*.

The following outbreaks of grasshoppers have occurred in the Southern districts of the Presidency, October-November :

At Tinnevelly : On *Cumbu* (*Pennisetum typhoideum*) :—

1. *Acrotylus humbertiana*, Sauss.
2. *Aiolopus affinis*, Bolivar. *Aiolopus tamulus* ; Madura.

At Ramnad, on cotton in March :—

1. *Catantops annexus*, Bolivar.

On *Ragi*, etc., in October :—

1. Chiefly *Oedaleus abruptus*, Th.
   Commonest in the South.
   Chrotogonus. *C. saussurei*, Bolivar.
   In the Circars : *C. robertsi*, Kirby.

I find a Psychid on gold mohur trees (*Poinciana regia*) ; it is very bad at Dacca.

Saluria inficita was found last year as a pest on dry land paddy in Mysore. It is not found to attack *Ragi* at all. The attack is similar to its attack on *Ragi* in Madras.

We have also recently had a case of Elaterid larvæ attacking paddy but the specimens could not be reared.

Elaterid larvæ were found damaging cereals at Pusa in December last.

Did these larvæ attack high-land paddy in Madras ?

No ; delta paddy. The larvæ were under the mud.

Have you found any parasite of *Pempheres* ?

Yes. I found a grub which we were unable to rear. Both adults and larvæ are killed by a fungus which our Mycologist is studying.

On 21st September 1920 I found *Oxycetonia jucunda* feeding on Chrysanthemum flowers in the garden at Dow Hill, Kurseong (elevation 6,000 feet).

To my list of crop pests two more Scolytids may be added; (1) *Hypothenemus erudita*, Westw., which bores into *cumbu* stems, and (2) *Xyleborus parvulus*, Eich., which bores into coconut stems.

On page 178 of the Proceedings of the Third Entomological Meeting, the distribution of *Anatona stillata* has been shown to be confined to Southern India, but the species has been found to occur in Northern India also; specimens have been taken at Dehra Dun and W. Almora, U. P.

The following additions to the Agricultural crop-pest list may be of interest :—

Popillia birmanica, Arr., eating roses, Lakhimpur, Assam.
Adoretus bombinator, Burm., eating roses, Lakhimpur, Assam.
Adoretus versutus, Har., eating roses, Lakhimpur, Assam.
Torynorrhina opalina, Hope, defoliating apricot, West Almora.

3.—SHORT NOTES ON NEW AND KNOWN INSECTS FROM SOUTH INDIA.

(Plates II—VI).

By T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., *Assistant Entomologist, Madras.*

To the Proceedings of the last Meeting of Entomologists held in 1919, I contributed a paper under the title "Some insects recently recorded as injurious in S. India" (see paper No. 3, page 314 in the Report of the Third Meeting of Entomologists, Pusa, 1919). On the present occasion I have attempted to submit to you a further instalment of notes on different South Indian Insects which I have been able to make during the past few years. Of the insects in this list some are forms new to science while others are already known ones; with regard to the latter only such notes which in my opinion are new or not recorded till now are added. While my last paper was purely an economic one treating as it did of injurious insects only, in this paper I have not specially confined myself to forms of economic importance alone, but have included both general and economic forms which might be of general interest. The brief notes added include records of some new forms and notes on synonymy, distribution, lifehistory, habits, etc.

Hymenoptera.

Bruchophagus mellipes, Gahan (Chalcididæ).

(The Daincha seed Chalcid.)

From a consignment of parasitic Hymenoptera forwarded to Dr. Howard of the U. S. A. Bureau of Entomology, a couple of years ago, Mr. A. B. Gahan recently described a species under the name *Bruchophagus mellipes* (*vide* page 513, *Proc. U. S. A. Nat. Mus., Vol.* 56; 1919) and we received named specimens of the same. On looking at the insect I had some doubts as to whether this was not the same species which Girault had named *Eurytoma indi* (see page 315 of my last paper in 1919). I raised this doubt and we wrote back to Mr. Gahan, who has replied that both the insects are one and the same, and that, since Girault's name was not yet published, this new name *Bruchophagus mellipes* should have priority. It might be seen that I had myself

made a foot-note in my last paper that this insect might be closely allied to the American clover seed Chalcid and evidently it is so, as both belong to the same genus (*Bruchophagus*). Thus the Daincha seed Chalcid is to be known in future as *Bruchophagus mellipes*, Gahan, and not as *Eurytoma indi*.

Stomoceras ayyari, Gahan (Chalcididæ). (Plate II, fig. 1.)

This jet-black, fairly large stout Chalcid was reared out from caterpillars of the Limacodid moth, *Parasa lepida*, a well-known pest of castor, mango, palms, etc., in the Plains of South India. More than one species of parasite has been reared from this larva but this one appears to be fairly important and a large-sized species. The insect was named and described by Mr. Gahan of the U. S. A. Bureau of Entomology (see page 518, *Proc. U. S. A. Nat. Mus.*, Vol. 56 ; 1919).

Spinaria nigriceps, Cam. (Braconidæ). (Plate II, fig. 2.)

On page 9 of the Pusa Bulletin No. 89 (Second Hundred Notes on Indian Insects), Mr. Fletcher has recorded *Spinaria leucomelæna*, Westw., as having been collected by him in Coorg. Recently I collected two specimens of a species which I am almost sure belong to the species which Cameron has described from Ceylon as *Spinaria nigriceps* (*Vide* page 37, Pl. 3, fig. 7) in *Manchester Memoirs*, XLI (4). This is evidently the first record of the species for Continental India.

So far we have the following species of *Spinaria* found in the Indian region :—

1. *Spinaria nigriceps*, Cam. Ceylon and Madras. (*Manchester Memoirs*, 1897).
2. *Spinaria trimaculata*, Cam. Khasi Hills (*Manch. Memoirs*, 1900).
3. *Spinaria albiventris*, Cam. Khasi Hills (*Manch. Memoirs*, 1899).
4. *Spinaria leucomelæna*, Westw. Coorg (*Pusa 2nd Hundred Notes Bulletin*, page 9).
5. *Spinaria flavipennis*, Cam. India (*Entomologist*, 1906, p. 205).
6. *Spinaria chotanensis*, Cam. India (*Entomologist*, 1906, p. 206).
7. *Spinaria spinator*, Guer. India (Duperrey, *Voy. Coquill., Zool.* II, p. 199, 1830).

Pristomerus euzopheræ. (Ichneumonidæ.)

In the Fauna volume on Ichneumonidæ, Morley described a new species under the name *Pristomerus testaceus*, a parasite reared out

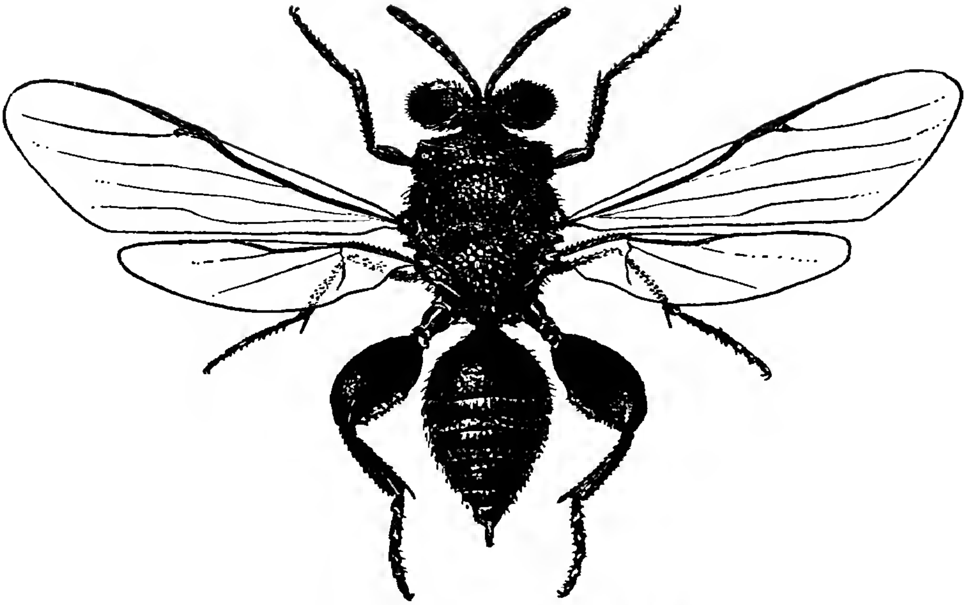


Fig. 1.—*Stomoceras ayyari*, Gahan (×8).

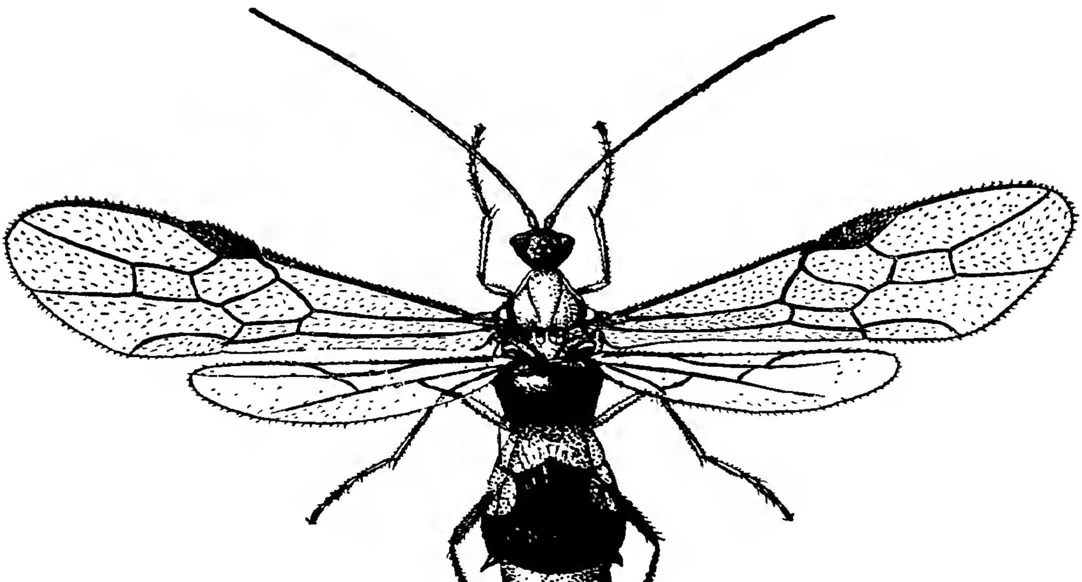


Fig. 2.—*Spinaria nigriceps*, Cam. (×7).

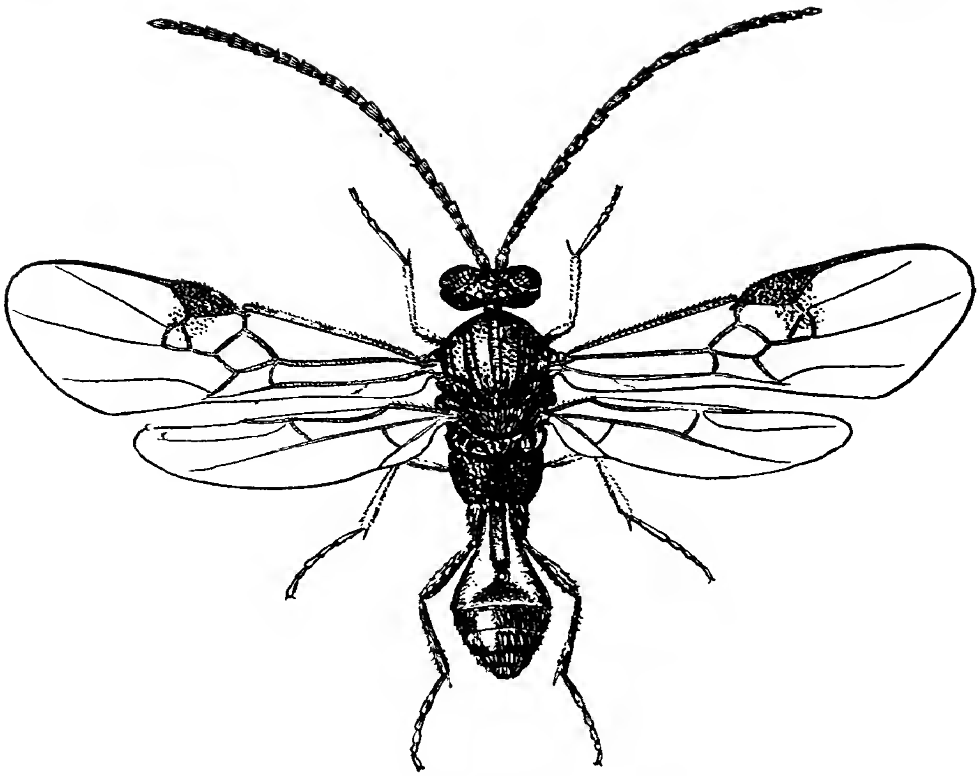


Fig. 1.—*Microplitis* sp. (×16).

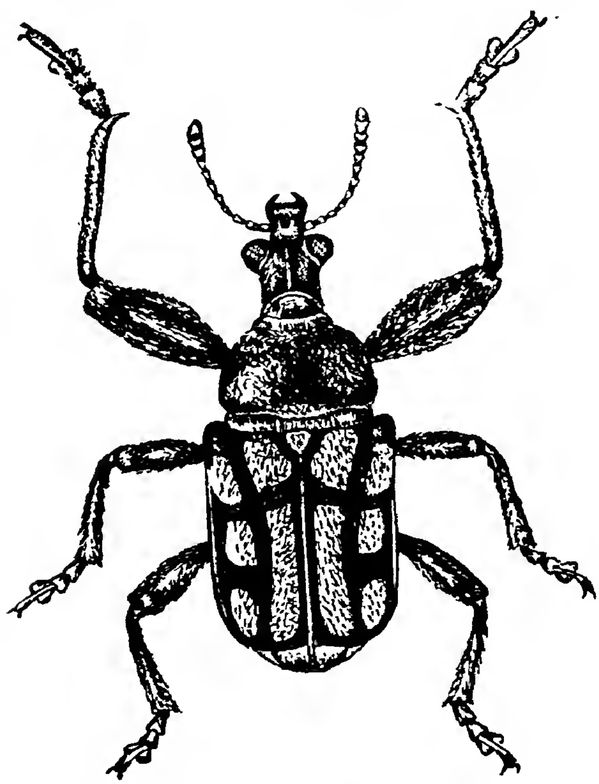


Fig. 2.—*Attelabus discolor* (×6).

from the Brinjal stem-borer, *Euzophera perticella*, Bag., collected at Attur, Chingleput, etc. I have recently come across a species of *Pristomerus* described by Viereck under the name *P. euzopheræ* which also appears to have been reared out from the same host caterpillar, in Mysore, in the *Proc. of U. S. A. Nat. Mus.*, Vol. 42, 1912-13, p. 152. It might be that the two are separate but as far as I could compare the descriptions, the species appear more or less similar. Whether the same or not, this additional information may be of use to workers on Ichneumonidæ in India. If they happen to be the same, Viereck's name being the earlier must be retained.

Microplitis sp. (Braconidæ). (Plate III, fig. 1.)

Most of us Indian workers are familiar with this pretty common insect found as a parasite on the castor semilooper, *Achæa (Ophiusa) janata*, in all castor-growing tracts. The parasitic grub after feeding inside the host comes out just before pupation, prepares a pale brown cocoon and fixes itself under the tail-end of the host-caterpillar. In certain seasons this insect acts as an important natural check on this pretty bad pest of castor and hundreds of parasitized larvæ are seen on the plants. This insect is a small bluish black active Braconid wasp. I submitted specimens of this insect to Mr. Viereck who has determined it generically. I hope to publish a detailed description as soon as possible after referring to literature and making myself sure that it a new species.

A Wood-wasp from South India. (Siricidæ.)

Recently while sorting out the Hymenoptera in the Coimbatore collections I came across a specimen of a wood-wasp belonging to the family *Siricidæ*, members of which are said to be very rare in the Tropics. Our insect was collected from Yercaud in the Shevaroy Hills at 4,000 feet elevation. On referring to literature, which I was able to get at, the insect appears to belong to the genus *Urocerus*, Geoff. (*Sirex*, Linn.), but I am not quite sure. It might be a species of the closely allied genus *Xiphydria*, Latr. of which Cameron has recorded one species, *Xiphydria quadrimaculata*, from the Khasi Hills (page 4, *Manchester Memoirs*, XLIII (3) ; 1899) and another, *Xiphydria striatifrons*, from Ceylon (page 70, *Spol. Zeyl.*, *III* ; 1906). This insect does not appear to be either of these. There is mention made of another species, *Xiphydria orientalis*, Westw., as also Indian but I am unable to get details of this latter. The importance of this record consists in the fact that this is the first record of a wood-wasp from South India so far as I know.

New South Indian Saw Flies. (Tenthredinidæ.)

Till now the only known saw-fly that has been recorded from South India appears to be the mustard saw-fly (*Athalia proxima*, Kl.). This is certainly not due to the absence of forms but solely because no collections were made and worked out till now. The three new species, including one new genus, mentioned below were collected by my colleagues and myself chiefly from the Hills of South India. Mr. Rohwer of the U. S. A. Bureau of Entomology was kind enough to name the species for us ; no publication of the descriptions has appeared as far as I know.

1. *Senoclia diascoreæ*, Roh. (MS) ; Taliparamba and Kollur (Western Ghats) 1,000-2,000 feet, found breeding on a species of *Diascorea* (July to October).
2. *Senoclia bilanga*, Roh. (MS) ; from the Nilgiris and Kollegal (September-October) from 1,000-2,000 feet elevation.
3. *Amonophadnus submetallicus*, Roh. (MS), from the Palni Hills, 5,000 feet (May).

All these are species with a uniform bluish-black colour without any yellow or reddish markings.

Pœcilogonalos spp. from South India. (Trigonalidæ.)

In a consignment of bees which I forwarded to Professor Cockerell a couple of years ago was included a specimen which I took to be a bee (*Nomada*). Professor Cockerell wrote back to me saying that the insect was a Trigonalid. He did not send me back the specimen nor did he publish anything regarding the same among our novelties among bees which he published in the *Annals and Magazine of Natural History* during 1919. Meanwhile I looked for more of these insects in our collection and succeeded in finding another Trigonalid. I had thus two specimens, one being the duplicate of the insect I sent to Professor Cockerell, and another one, both apparently different species. Finding these very interesting I referred to literature and found that from India, so far as I was able to make out, only one species had been described and that was *Poecilogonalos harmandi*. Under the circumstances I made bold to describe these two insects as two new species and these descriptions were published in the *Records of the Indian Museum*, XVI, pp.71-74 (1919) under the following names :—

1. *Pœcilogonalos fulvoscutellata*, from the Palni Hills (May).
2. *P. kerala*, from Malabar (October).

I now find that Professor Cockerell has very recently published a description of the insect I sent him, in the *Proceedings of the Ento-*

mological Society of Washington, Vol. XXII, page 191, as a new species with the name *Pœcilogonalos mimus*. From the description I am almost sure that this is the same as my *Pœcilogonalos fulvoscutellata*. If both these happen to be same, Professor Cockerell's name must sink and mine should have the priority, having been published earlier.

Coleoptera.

Attelabus discolor, Fb. (Plate III, fig. 2.)

This pretty weevil was noted in December last in the Walayar forests, Coimbatore, on *Terminalia* shoots. They were found in good numbers twisting the leaves into characteristic knots and doing some appreciable damage. It was found in company with *Apoderus echinus* and *Attelabus* 8-*punctata*. This has been noted before by Stebbing in the Coimbatore district on *Anogeissus latifolia*.

Lablab vine gall-weevil. (Curculionidæ.)

In the Kistna delta, while engaged in paddy stem-borer work, I noticed that in the main vines of *Dolichos lab-lab* were found prominent galls close to the ground level. On cutting open the gall a weevil was found to breed inside the spongy matter. The gall is about the size of a man's fist. I am unable to state whether the gall was produced by the weevil or whether the weevil selected the gall for breeding purposes after its formation. The weevil is dark brown in colour and stoutly built. In appearance it resembles more or less a species of *Desmidophorus*.

Morinda shoot-borer beetle. (Scolytidæ.)

In my last paper I have made reference to this insect as a borer into the tender shoots of *Morinda tinctoria* in Coimbatore. This insect has recently been identified as *Hypothenèmus plumeriæ*, Nor. The insect does some damage to the tender shoots and attacked-shoots drop down faded, which indicates the presence of the pest.

Aræcerus fasciculatus, DeG. (Anthribidæ).

This well-known beetle has recently been found to breed inside fruits of the Persian Nim tree (*Melia* sp.) in numbers on the Coimbatore farm. Though a well-known pest of areca-nuts in India, I have not yet come across this insect on areca nor have we received any definite reports regarding the damage done by this insect till now from the West Coast tracts which have extensive areca gardens.

Leafbeetles on pepper. (Chrysomelidæ.)

A number of small leafbeetles have been noted on the pepper vines biting holes in the leaves in North Malabar. Of these only one, *Longitarsus nigripennis*, Mot., has been so far noted to be a specific pest of pepper, contributing its share in causing "Pollu" disease. Others often noted on pepper are (1) *Pagria costatipennis*, Jac.; this is a small dark coppery-brown insect looking more or less like the grape-vine flea-beetle (*Scelodonta strigicollis*). It is very active and often found in numbers on the tender foliage, (2) *Neculla pollinaria*, Baly; this insect at first sight might be mistaken for a weevil of the genus *Myllocerus*. It is short, stoutly built and brown in colour; the whole body is completely covered by a thick ashy down which gives it the colour of a *Myllocerus* species. (3) *Nisotra madurensis*, Jac. This is a well known insect affecting *Hibiscus*, Jute, etc., in South India, and has been occasionally found on pepper in North Malabar.

LEPIDOPTERA.

Asura conferta, Wlk. (Arctiadæ.)

The hairy larva of this moth is found to be a domestic pest in the villages along the Western Ghats during the months from August to October. It is especially found on mossgrown walls and old buildings with the roof covered with small country tiles. Often the caterpillars drop down into the living apartments of houses and cling to clothing, etc. The irritation produced by its contact is pretty severe and the part of the skin gets swollen. Children are often put to great annoyance in houses by the contact of these hairy caterpillars. The caterpillar which is found feeding on the moss and basking on the tiles during the damp steamy weather settles on walls and protected corners inside the woodwork of the roofs before pupation. At this stage it makes a sort of oval enclosure with its hairs and in the centre of the oval area it builds the cocoon and changes into the pupa. The adult insect, which is a pretty moth, is often seen coming to lights at night. The name *asura* appears very appropriate, at any rate, considering the local tradition that this pest generally disappears after the annual festival called "asura samhara" (the destruction of *asura* or demon) in the month of November in Palghat, where the insect is found every year.

Pelochyta astræa, Pr. (Arctiadæ.)

This pretty moth is fairly common in Coimbatore. There is one very interesting character in this moth which I have noted and which

I have not found recorded as far as I know. The moth, which is rather slow flying, when caught emits a frothy juice from the prothoracic region near the root of the wings. The fluid is yellowish green and has a frothy consistency. This is perhaps a protective adaptation to repel natural enemies. On two successive occasions I found this moth on *Ficus glomerata.*

Cricula trifenestrata, H. (Saturniadæ.)

In the pepper gardens of North Malabar this wild silk insect is very commonly found. It chiefly attacks cashew and mango trees. Often, the standard trees on which the pepper vine grows up are subject to the attentions of this insect. The tree *Careya arborea* often suffers considerably from this insect. The whole foliage of the tree is completely stripped and on the stems and forks of the branches may be seen masses of golden yellow cocoons of these caterpillars. And often the caterpillars are found to pupate in masses under cover of pepper leaves also ; but so far no appreciable damage has been found to be done to pepper vines.

Stauropus alternus, Wlk. (Notodontidæ.)

This insect has occasionally been noted in small numbers on red gram, Tamarind, etc., in Coimbatore. In December 1919 in the Walayar forests, I found small plots of red gram (*Cajanus indicus*) very badly infested by these caterpillars. But one remarkable point in the case was the heavy parasitization of the worms. More than 90 per cent. of the larvæ were parasitized by a Braconid (*Apanteles* sp.).

Casuarina seedling caterpillar. (Pyralidæ.)

This is a new pest reported from the Coast tracts of Tanjore district near Negapatam where Casuarina plantations are found. This insect is a slender pale green elongated caterpillar which lives by day under the soil near the young plants in tubular galleries of sand and during the night comes out and cuts the tender plants carrying portions of the cut shoots into the burrow underneath. In habits I found the creature exhibiting the same features at *Ancylolomia chrysographella*, which I saw in the sandy coast fields of Cannanore in North Malabar in June 1908. The Casuarina plantations are practically on the sandy sea coast and it is only the very young plants that are found to suffer.

Schœnobius bipunctifer, Wlk., at lights. (Pyralidæ.)

That the female of this insect is attracted to lights was noted by me as early as April in 1907 when I was sent to investigate the pest in

response to a serious report from the Anantapur district. Later on, in December of the same year, I visited Narsapur taluq in the Kistna district and found that my original observation was further confirmed by seeing hundreds of the female insects dashed against house lights all along the canal in the paddy deltas. Though I am unable to state definitely at present whether light traps will prove an efficient control for this pest or not, I feel that we have not enough grounds to warrant us to condemn this method even to the smallest extent. As such I am unable to agree with the statement made under this insect on p. 121 of the *Proceedings of the Third Entomological Meeting* at Pusa, 1919. In 1919 on a certain night during the Christmas holidays I happened to be in one of the big railway stations situated right in the middle of a paddy area in Malabar. Here on the overbridge which was pretty high and commanded a good distance, a power light was put up. Around this light, I found thousands of *Schœnobius* females hovering about; at a moderate estimate the number was no less than 5,000. Another important phenomenon I noticed was that on the framework of the bridge below the light were found hundreds of eggmasses laid by gravid females; some moths were even actually found depositing their eggs. From these and similar observations I feel that this method has to be tried properly and at the proper season to make us come to some definite conclusions on this point.

Dactylethra candida, Stt. (Gelechiadæ.)

The Kolingi plant (*Tephrosia purpurea*), a valuable green manure weed, harbours a small caterpillar which breeds inside the pod-forming flowers of this plant all along the Coromandel Coast, in Negapatam, Tanjore, South Arcot, etc. The flowers do not form ordinary pods but, due to the irritation caused by the caterpillar, a globular gall is formed, inside which the larva remains feeding and pupates. It is very commonly found during the months of May-June. The moth is a small pale whitish insect.

Ergolis merione, Cr. (Nymphalidæ.)

This insect, which is noted as a pest of castor in different parts of India, has not been noted so far as I know in South India. I saw the insect as a pest of castor on the Samalkot farm and Pithapuram in 1907, and I have never noted the insect or any allied species as a pest of castor anywhere in the south. Mention is made of this in the last Proceedings (page 107) but I believe this information regarding the locality-distribution, showing the southern limit up to which it is found as a pest of castor, may be of interest.

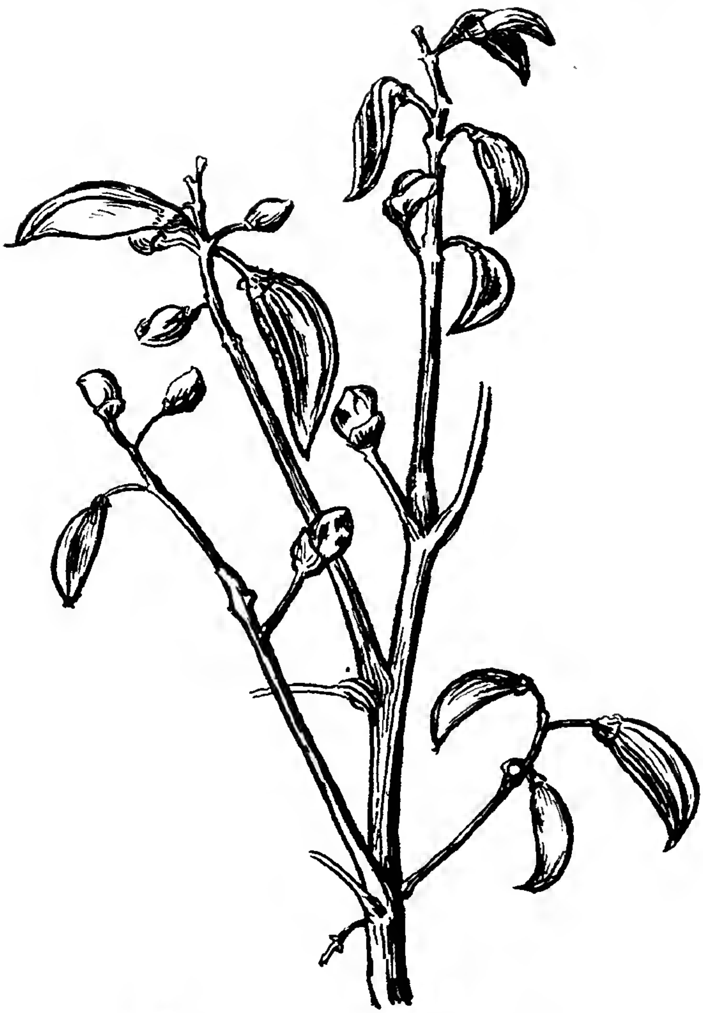


Fig. 1.—Healthy *Pongamia* fruits.

Fig. 2.—*Pongamia* attacked by Gall-fly.

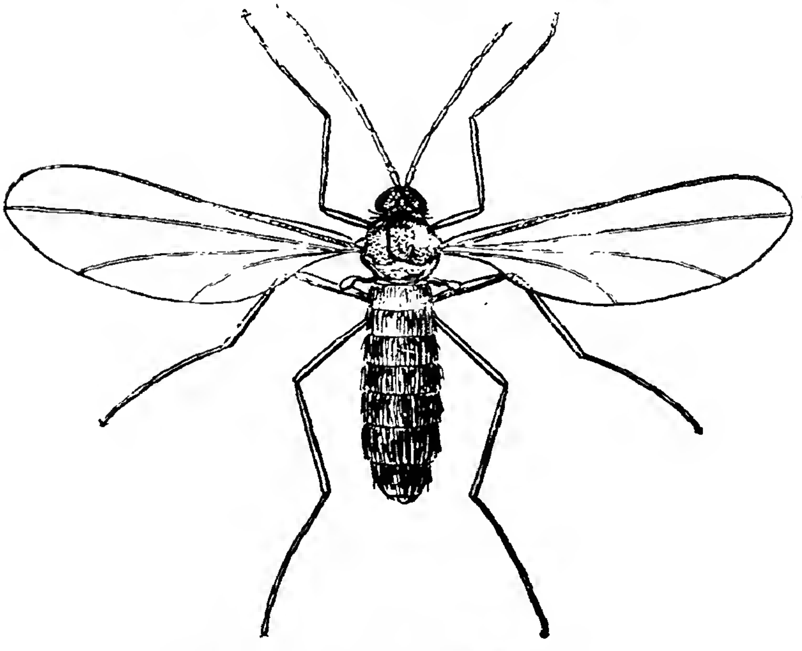


Fig. 3.—*Pongamia* Gall-fly × 13

Pongamia Gall-fly.

DIPTERA.

Biting Flies on the Bababuddin Hills. (Tabanidæ.)

During the month of May, when a few early thunder showers have fallen, two or three kinds of Tabanid flies of the genus *Hæmatopota* are generally found on the Bababuddin Hills in Mysore. These flies not only attack cattle but bite men also viciously. During this season cartmen very reluctantly take their bulls up the Hills. While on a collecting trip a few years ago, I found it very difficult to remain on the hills due to the annoyance of these insects. Two species of this genus collected by me have been described by Miss Ricardo in the *Annals and Magazine of Natural History* for February 1917 (p. 225) as *H. hindostani*, and *H. montansis*.

Pongamia gall fly. (Cecidomyiadæ). (Plate IV.)

In many parts of South India, especially in Bangalore, Coimbatore, and other places, I have seen that the fruits of the tree *Pongamia glabra*, which under normal conditions should be almond shaped, are in many cases found deformed into clusters of small round gall fruits. On the same tree and often on the same branch both the kinds of fruits are commonly formed. For a long time I thought the growth was natural. Recently I found that this small round gall fruit was a mal-formation and due to the work of a gall-fly. I have reared out the flies in numbers and specimens have been forwarded to Dr. E. P. Felt for identification. It is probably common in other parts of India also.

RHYNCHOTA.

Deltocephalus dorsalis, Mot. (Jassidæ). (Plate V, fig. 1.)

Though this leaf-hopper has been recorded as enjoying a fairly wide distribution, it has not been noted as an injurious insect till now. In June 1919 this insect was found in swarms on a paddy nursery in the Kistna Delta and so far as I could judge appeared to be responsible for the damage to the foliage which was characteristic of leaf-hopper bugs and which resembles exactly that caused by *Nephotettix bipunctatus* on paddy.

Disphinctus humeralis, Dist. (Capsidæ.)

This insect has not been recorded from South India till now. I noted it in some numbers on a species of wild Solanum on the Wynaad Hills (2,500 feet elevation) in October. This is an insect which may

have to be watched in South India as it has been noted on tea in Assam and on Cinchona in Sikkim.

Cinnamon Psylla. (Psyllidæ.)

In South Kanara district, especially around Mangalore town where cinnamon plants (*Cinnamomum camphora*) are found growing wild as hedge plants in the deep paddy valleys, I found a Psyllid producing galls on the foliage and causing appreciable damage to the plants. Though not a cultivated plant in the tract the cinnamon plant is of economic importance and as such a note regarding this insect may be of some interest. The Psyllid is a very active creature with transparent wings, quite unlike the spotted wings of the *garuga* Psyllid (*Phacopteron lentiginosum*, Buck.) or the *Cardia* Psyllid of Coimbatore (*Euphalerus citri*, Gr.). It resembles to some extent the Psyllid I got on *Ficus nervosa* in Taliparamba (see my paper, No. 82, *Proc. Third Entl. Meeting*, 1919), but it is not the same.

Cosmoscarta niteara, Dist. (Cercopidæ). (Plate V, fig. 2.)

All along the Western Ghats from South Kanara down to the Wynaad Hills the commonest species of this genus is found to be *Cosmoscarta niteara*, Dist. In most cases when I noted the insect I have found it on the succulent top-shoots of the *sand-paper Ficus* plant (*Ficus* sp.). Large masses of white spittle produced by the insect are also noted on the top-shoots of these plants. The insect is fairly large and is beautiful in colour and extremely active. I did not note this on the jak tree which is the favourite foodplant of the other species, *C. relata*, Dist., in Coorg and Mysore.

New records of Coccids.

Since the publication in 1919 of my Bulletin on "South Indian Coccidæ" (Bulletin No. 87), I have been able to get the following further records of Coccidæ from South India :—

Parlatoria camelliæ, Comst., on stem of *Melia*, Coimbatore.
Parlatoria cristifera, Green (M.S), on *Citrus*, Maddur (Mysore).
Aspidiotus hartii, Ckll., on Turmeric, Erode (Coimbatore).
Chionaspis herbæ, Green, on grass, Coonoor (Nilgiris).
Pseudococcus bromeliæ, Bouche, on pine-apple, Taliparamba (Malabar).
Phenacoccus hirsutus, Green, on *Ficus indicus*, Kollegal (Coimbatore).
Antonina indica, Green, on grass roots, Coimbatore.
Walkeriana xyliæ, Green (MS), on *Xylia*, Taliparamba (Malabar).

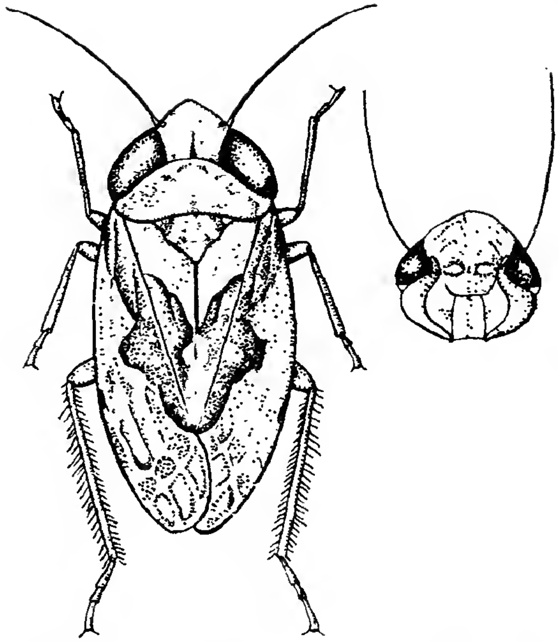


Fig. 1.—*Deltocephalus dorsalis* (×15).

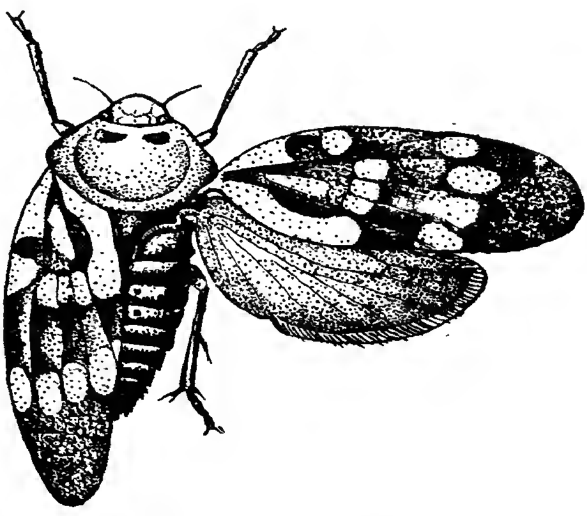


Fig. 2.—*Cosmoscarta niteara* (×2½).

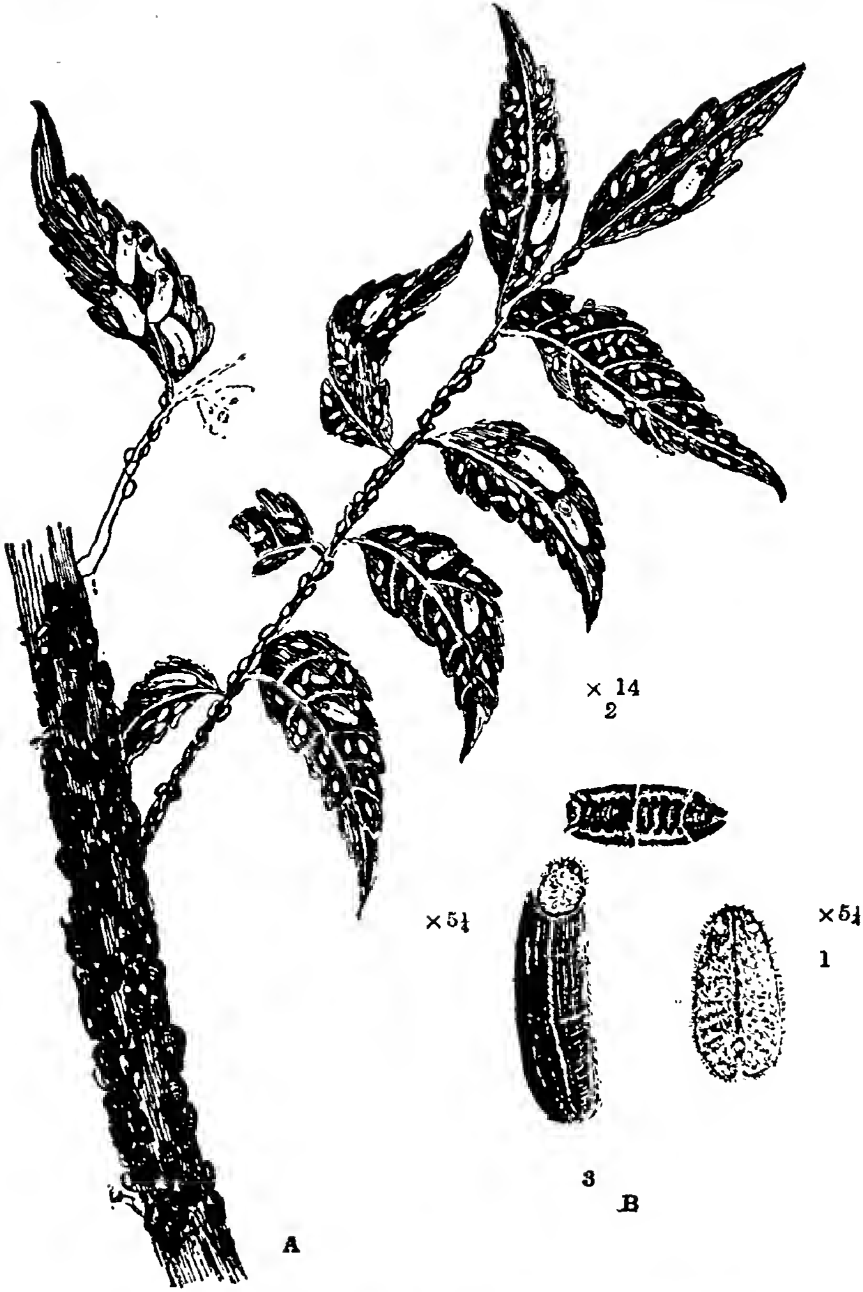


Fig. 1.—*Pulvinaria maxima*, Green. A, scale-infested branch of Nim ; B, 1, adult female, 2, male puparium, 3, female with ovisac.

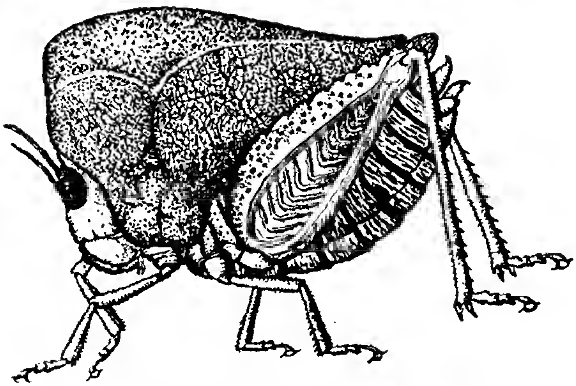


Fig. 2.—*Phyllochoreia* **sp.** ($\times 2\frac{1}{2}$).

Besides the above new records, which include also two undescribed species, several of the known forms have been noted on other host plants on which they have not been recorded till now from South India.

It may also be mentioned here that Mr. Green has since described all the new *Diaspidinæ* mentioned as MS names in my Bulletin in the *Records of the Indian Museum*, Vol. XVI, pp. 433-449 (December 1919).

Pulvinaria maxima, Green. (Coccidæ.) (Plate VI, fig. 1.)

This Coccid has within the last few years made very good progress as an important pest. In the early years it was noted only on the *nim* tree (*Melia*) around Coimbatore. Now the insect has not only been found to have a wider distribution but is asserting itself as a pest of more than one important plant. Within the last three years the insect has so far been noted in Mysore, Tinnevelly, South Arcot, Madura and Kistna districts. The main host plant on which the insect revels is the *nim* but it has been found occasionally in fairly large numbers on cotton, mulberry, garden croton and *Jatropa curcas*. On the last plant I saw it very bad in a delta village in the Kistna district last year, actually killing many shrubs. I think this is one of those insects the activities of which demand watching.

ORTHOPTERA.

Trachythorax planiceps, Redt. (Phasmidæ)

In the *Bombay Natural History Society's Journal*, XXII (1913), p. 641, I published a note containing some observations on the life-history of an interesting Phasmid which I reared out from the egg stage. At the time of publication of the note I was under the impression that the insect might be a species of *Calvisia*. Sometime ago I received information from Senor Candido Bolivar, of Madrid, that the insect belongs to the species *Trachythorax planiceps*, Redt.

Phyllochoreia sp. (Eumastacinæ.) (Plate VI, fig. 2.)

During my tours in North Malabar I have collected an interesting Eumastacine grasshopper which is undoubtedly a species of *Phyllochoreia* (see figure). In the *Fauna* volume on grasshoppers, Kirby has recorded two species which come near this insect in general form *viz.*, *P. equa*, Burr, and *P. asina*, Burr. But as far as I could make out the insect under review appears a new species. It is quite common at Taliparamba in N. Malabar from September to November and is found in all stages (I did not find the eggs) chiefly on *Xylia* and *Terminalia* bushes, nibbling the tender foliage. In the presence of the broad

leafy thoracic shield and in coloration the insect is very well protected; it is often found very difficult to make out the presence of the insect on the leaves due to its protective resemblance.

THYSANOPTERA.

As a supplement to my paper on "Thysanoptera" read at the last meeting (see page 618 of the Report), the following further information on some South Indian species may be of interest. In April 1919 we forwarded to Mr. Bagnall a consignment of Thysanoptera collected from different parts of South India and found on a variety of plants. Of these, Mr. Bagnall has since described the following new species in the *Annals and Magazine of Natural History* for October 1919 :—

(1) *Dendrothrips indicus*, on leaves of arrow-root plants, in company with *Panchætothrips indica*, Bgll., North Malabar (September).

(2) *Euthrips citricinctus*, on arrow-root leaves, North Malabar (September).

(3) *Haplothrips pictipes*, in diseased pepper berries, North Malabar (September).

The bulk of the material sent is still unidentified. Later on we sent him specimens of an interesting species of large sized Thrips collected on *Eugenia wrightiana* by Mr. Muliyil on the Palni Hills; Mr. Bagnall has identified this as a species of *Leeuwenia*, almost certainly *L. indicus*, Bgll. This species is a member of the group Hystrichothripidæ. Species of *Leeuwenia* noted elsewhere till now also appear to have been found on species of *Eugenia* plants only.

It may also be added that recently I have noted a species of Thrips doing severe damage to leaves of garden crotons both in Bangalore and Coimbatore. The foliage becomes thickly spotted and sickly and gradually fades. The adult is dark brown with the anal end reddish, young ones are pale whitish.

4.—OXYA VELOX.

By Rao Sahib Y. Ramachandra Rao, M.A., F.E.S., *Assistant Entomologist, Coimbatore.*

Oxya velox, the lesser or small grasshopper of Paddy, is a greenish insect with a lateral yellow stripe. The female is light to bright green and reaches in some cases 2 inches in length, while the male is more slender and smaller and usually reddish brown in colour.

Foodplants. It is on the whole a marsh insect, feeding on grasses growing in wet situations. The young ones as well as the adults attack the leaves of paddy, especially in the nurseries, while the adults are capable of doing much damage to paddy in ear by biting at the bases of the maturing earheads and causing them to dry up. The grasshopper is also known to attack cotton and pulses.

Life-history. In adaptation to a life in marshes the grasshopper has acquired peculiar habits of oviposition. While in dry weather and in dry conditions the insect may lay eggs in the soil like other grasshoppers, in marshy situations it lays eggs among paddy stems and grass-clumps about an inch or two above the water-level. It exudes a gummy frothy liquid which soon sets hard, assuming a red-brown colour, and serves to protect the masses of eggs laid in its midst. In certain instances such eggmasses were also found laid in folds of cotton leaves in a cotton field and likewise in folded paddy leaves.

The number of eggs in a mass laid in the field was found to vary from 10 to 29.

The duration of the egg period was found to vary from 15 to 41 days, and was observed to depend chiefly on the season of the year and the presence or absence of moisture. It was shortest in April, 15-17 days, and longest in December and January, 41 days.

The young ones. The sexes can be distinguished even in the earliest stages chiefly by the aid of characters of the anal appendages.

The males invariably pass through 6 moults, while among the females there is in about 50 per cent. of the cases an additional moult. The wing-pads are noticeable even in the first instar and in the earlier stages are found overlapping the sides of the thorax, but after the fourth moult and after the fifth in the case of certain females, the wings become turned back.

The grasshopper breeds throughout the year, but is found in largest numbers in the rainy season, August-November.

The grasshoppers would seem to copulate more than once.

In eleven cases of grasshoppers which laid eggs in cages the largest number of eggs laid by a single individual was 177 (distributed among 12 egg-masses); in other cases there were 163, 132, and 131 (11 egg-masses) and 113 (8 egg-masses) and 109 (7 egg-masses).

Natural Enemies.

Predators. Frogs and birds.

Parasites. On Hoppers:

(1) One Sarcophagid was reared at Coimbatore.

(2) Mites on adults.

On Eggs. Owing to the exposed situation of the egg-masses these appear to be subject to the attack of numerous parasites.

(1) Minute brown Chalcidid, *Tumidiscapus oophagus*, Gir., 17-21 individuals in each egg: pupation period 6 days: whole life-cycle about a month. Hyperparasitized by a large green Chalcidid (*Aximopsis tumidiscapi*, Gir.).

(2) Black parasite—depressed abdomen.

(3) Black Proctotrypid (*Scelio oxyœ*, Gir.)—compressed abdomen. Life-cycle—1½ months.

(4) Large bluish green parasite (Chalcidid) (*Anastatus coimbatorensis*, Gir.)

Remedial measures.

(1) Ploughing is of no use in the egg stage.

(2) Collection of eggmasses is contra-indicated owing to the presence of parasites.

(3) Bagging when present in large numbers.

Was such ovi-position found to be very extensive?

When the paddy was three to four months old we were able to collect a large number of eggs from a single field.

5.—FIRST ENTOMOLOGICAL RECORDS IN PORTUGUESE INDIA.

By MAJOR FROILANO DE MELLO, *Bacteriological Institute, Nova Goa and* P. CORREA AFONSO, *Department of Agriculture of Portuguese India.*

INTRODUCTION.

It is necessary that we should state, before entering into the subject of this paper, that research in General Parasitology, as applied to Medical Science or to Agriculture, was started in Portuguese India only six years ago.

It must be admitted that in a small country, as ours is, a medical officer or an agricultural one cannot devote his full time to one particular subject of investigation out of the many which constitute the Medical or the Agricultural sciences. Their attention is bound to be dispersed over a diversified field of work. Moreover, in countries which are, almost beyond hope, buried under deep strata of routine, any new introduction or suggestion gives rise to a movement of reaction on the part of the majority of the people. They discourage the workers either by a studied attitude of cold indifference or by direct manifestations of hostility, the result being that the better part of the work is lost on unreceptive minds and the energies of workers are very much hampered. Such in fact is, unfortunately, the position of the writers.

These few statements will serve as a justification of, or an apology for, the fact that the entomological notes which are herein recorded are very scanty indeed and have not been arranged in accordance with any systematic plan, as might be desired. The identifications were made in the short intervals of freedom snatched between periods of regular official duties.

The writers hope that they will meet with the favour of a kind acceptation from the scientists assembled in this Conference, being thereby induced to follow up their investigations with perseverance and method. They likewise ardently hope that your favourable acknowledgment of their work may be readily noticed by the people of this country, and being accepted by them as an honour done to the country as a whole, may stimulate them to give to the writers that hearty cooperation which is essential for the progress of our work.

Before proceeding to give a list of the insects identified by us, we have much pleasure in requesting the Entomologists assembled at this conference, particularly the Imperial Entomologist, to give us not only encouragement but also their scientific aid in the work which we further propose to take in hand, it being clear that the brief notes recorded in this paper are only a short preface to a more elaborate undertaking for the future.

Medical Entomology. The following is the note of the species up to date recorded. Each species is followed by the name of the place where it was collected.

DIPTERA.

FAMILY CERATOPOGONINÆ.

Genus *Ceratopogon*. *C. albonotatus*, Kief. Nova Goa, Daman.

„ *Culicoides*. *C. pattoni*, kieff. Nova Goa between December & February.

FAMILY SIMULIDÆ.

Genus *Simulium*. *S. striatum*, Brunetti. Dudsaghor.

FAMILY PSYCHODIDÆ.

Genus *Phlebotomus*. *P. minutus*, Rond., Very common in rainy months; *P. malabaricus*, Annandale, Colem.

FAMILY CULICIDÆ.

Genus *Anopheles* (*S. lato*). *A. rossi*, Giles, whole province; *A. stephensi*, Liston, Nova Goa, Pragana, Daman, Diu; *A. ludlowi*, Theob., Nova Goa, Daman. *A. leucosphyrus*, Donitz, Sanquelim; *A. funestus* var. *listoni*, Liston, Diu, Daman, Nova Goa, Satary; *A. culicifacies*, Giles, Nova Goa, Sanguem, Satary, Daman; *A. barbirostris*, Van der Wulp, Nova Goa, Daman, Diu, Satary; *A. jamesi*, Theob., whole India; *A. pulcherrimus*, Theob., Novas-Conquistas; *A. sinensis*, Wied., Daman; *A. maculatus*, Theob., Sanquelim; *A. fuliginosus*, Giles, Daman; *A. rossi* var. *vagus*, Donitz., Nova Goa.

Genus *Rachionotomyia*. *R. aranoides*, Th., Nova Goa (identified by Mr. R. Senior-White).

Genus *Culex*. *C. fatigans*, Wied., Nova Goa.

Genus *Stegomyia*. *S. fasciata*, Fabr., Whole India; *S. albopicta*, Skuse, *ibid*.

FAMILY TABANIDÆ.

Genus *Tabanus*. *T. bicallosus* (?), Pragana; *T. ditæniatus* (?), Nova Goa; *T. striatus*, Fabr., Colem; *T. albimedius*, Wlk., Nova Goa; *T. indianus*, Ricardo, Caranzol (identified by Mr. R. Senior-White).

FAMILY TABANIDÆ—*contd.*

Genus *Corizoneura*. *C. taprobanes*, Wlk., Pragana.

Genus *Chrysops*. *C. dispar*, Fabr., Nova Goa.

FAMILY ASILIDÆ.

Genus *Philodicus*. *P. javanus*, Wied., Nova Goa, Bicholim.

FAMILY MUSCIDÆ.

Genus *Lucilia*. *L. argyricephala*, Mg., Whole India.

Genus *Chrysomyia*. *C. bezziana*, Villen., myasis-producing fly, Nova Goa.

Genus *Musca*. *M. nebulo*, Fabr.; *M. bezzii*, Patt. & Cragg; *M. humilis*, Wied., Nova Goa.

Genus *Philæmatomyia*. *Ph. crassirostris*, Stein, Nova Goa.

Genus *Stomoxys*. *S. calcitrans*, L., Nova Goa.

Genus *Lyperosia*. *L. minuta*, Bezzi, Nova Goa.

FAMILY HIPPOBOSCIDÆ.

Genus *Lynchia*. *L. maura*, Bigot, whole India.

Genus *Hippobosca*. *H. maculata*, Leach, Nova Goa; *H. capensis*, Leach, Nova Goa.

SIPHONAPTERA.

FAMILY SARCOPSYLLIDÆ.

Genus *Echidnophaga*. *E. gallinacea*, Westw.

FAMILY PULICIDÆ.

Genus *Pulex*. *P. irritans*, L.

Genus *Xenopsylla*. *X. cheopis*, Roth.

Genus *Ctenocephalus*. *C. felis*, Bouche; *C. canis*, Bugis.

Genus *Ceratophyllus*. *C. fasciatus*, Bosc.

Genus *Ctenopsylla*. *C. musculi*, Auges.

Common in all parts of India.

RHYNCHOTA.

FAMILY REDUVIIDÆ.

Genus *Conorrhinus*. *C. rubrofasciatus*, de Geer, Nova Goa.

FAMILY CIMICIDÆ.

Genus *Cimex*. *C. hemipterus*, Fb., whole India.

ANOPLURA.

FAMILY PEDICULIDÆ.

Genus *Pediculus*. *P. capitis*, de Geer ; *P. vestimenti*, de Geer, Nitsch.
Genus *Phtirius*. *P. pubis*, L.
Genus *Hœmatopinus*. *H. tuberculatus*, Giebel ; *H. vituli*, Enderlein ; *R. spinulosus*, Burm.

Common throughout Portuguese India.

AGRICULTURRAL ENTOMOLOGY, (observations made only for the last two years).

LEPIDOPTERA.

1. *Hesperiadœ.*

Parnara (*Chapra*) *mathias*, Fb., appeared as a serious pest in some localities in 1918. It was not possible to collect the eggs. At the stage in which the larvæ were collected they were green, with a black head ; after a week's growth the head likewise turned green with two lines of dark green colour above the eyes. There is a dark green line running along the dorsal region from the head to the anus. Twelve days after collection, probably 15 days to 18 days after emergence from the egg, the larvæ had a length of 3 centimetres and entered the pupal stage within folds of rice leaves. Larvæ which pupated on the 4th of June emerged as moths on the 11th. The butterfly is two centimetres long, has dark wings with dots upon the first pair.

Two parasites were found to kill the larvæ, the one emerging from the cocoon being a Hymenopteron. The material was unfortunately lost before identification could be made. Rice fields from Salcele (1920), October 1920.

2. *Noctuidœ.*

(*a*) *Spodoptera mauritia*, Boisd.

(*b*) *Prodenia litura*, Fb.

These two pests appeared in large mixed swarms in 1919, the first having been also recorded singly in the irrigated crop of 1918.

They are said to have nocturnal habits ; such was, however, not the case during the attack above referred to ; the larvæ were found to be actively feeding even at 11 A.M. and 4 P.M. When they appear on an irrigated crop (November-March) the nocturnal habit is noticed. The pupæ of the insects which were reared were found to be among the roots of the rice plant at a depth of a little over 2 centimetres. Under natural conditions they are said to go deeper. The pupal stage lasted 8 to 10 days.

The larva of *Prodenia* is distinguishable from that of *Spodoptera* by a dark line traversing the thoracic segments ; this difference is not apparent at a young stage. Collected at Salcete.

3. *Nymphalidæ.*

Melanitis ismene, Cram. (Salcete).

A few caterpillars of this insect were found feeding upon rice in 1918. This is not a pest of any importance in Portuguese India.

4. *Pyralidæ.*

Nymphula sp. Quepem.

A species of *Nymphula* has been recorded every year from 1918 up to date on irrigated rice in several localities at some distance apart ; it appears early in December and is active for about fifteen days. It has also been noticed late in January, possibly as a second brood. This pest is again under observation in the current season and as far as possible the species will be identified.

Sylepta sp. (Salcete).

A species of this leafroller is common on *Hibiscus* plants in the rainy season.

5. *Gelechiadæ.*

Sitotroga cerealella, Ol., is a serious pest of stored paddy. It is a popular belief that this pest attacks only parboiled rice. It was, however, found in the current year (December) to attack raw paddy harvested in September. The moisture conditions which render stored paddy liable to the attack of this pest under Konkan conditions are being investigated.

6. *Papilionidæ.*

Papilio demoleus, Linn., has been recorded feeding upon lime and orange trees, eggs being laid in June and July, when the tender shoots appear. It is only tender shoots and leaves that are destroyed. (Salcete, Ichas).

7. *Arbelidæ.*

Arbela sp., recorded at Nova Goa boring into *Anona spinosa.*

COLEOPTERA.

1. *Dynastinæ.*

Oryctes rhinoceros, L., is a widespread coconut pest, more common in the coastal tract than in the interior of the country. It is active

particularly from August to October. The holes made by them upon the coconut palms are found to be mostly deserted in November (whole Port. India, specially Veehas Conquistas).

2. *Ptinidæ.*

Lasioderma serricorne has been found in cigars imported from Manila. It has not been observed on leaf tobacco imported from British India.

3. *Meloidæ.*

Meloid bettles of several species were found in August 1920 feeding on pollen of rice and riceland grasses. It is a pest of minor importance. (Salcete).

4. *Curculionidæ.*

Rhynchophorus ferrugineus, Fb., has been recorded as a widespread pest of coconuts. (Salcete, Ichas).

Cryptorrhynchus mangiferæ, Fb., is common on the late varieties of mango, particularly the Fernandina variety. (Veehas Conquistas).

Calandra oryzæ, Linn., is a serious pest of stored rice. (Whole Port. India).

5. *Cerambycidæ.*

Batocera rubus does considerable damage to mango tree trunks.

6. *Scolytidæ.*

A shot-hole borer of coconuts is found to do considerable damage. On account of its importance its study has been undertaken and its lifehistory will be worked out. It is a Scolytid beetle of unknown species. (Salcete).

7. *Chrysomelidæ.*

Aulacophora beetles are common on all kinds of cucurbits, but not as a serious pest.

HEMIPTERA.

1. *Coreidæ.*

Leptocorisa varicornis, Fb., is a rice pest of similar status.

These are a few of the insects of agricultural importance which have been recorded in Portuguese India. No mention has been made of such insects as have been merely observed, but the writers have had no opportunity of giving more attention to. Such as for instance, a cocount leafeating caseworm (possibly *Mahasena* sp), a mango shootborer, etc.

6.—AN ENTOMOLOGIST'S CROP PEST CALENDAR FOR THE MADRAS PRESIDENCY.

(Plate VII.)

By T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S., *Assistant Entomologist, Madras.*

It must be conceded that in any agricultural tract where sufficient experience has been gained of the behaviour of important crop pests over a fairly long period time, it might be possible for one to forecast the probable time of appearance of each pest during the different seasons of any normal year. Of course, many an Entomologist can easily recall the vagaries of different insects and quote instances of how an expected pest often deceives him by not showing itself and how it sometimes causes surprise by its sudden and unexpected appearance in another year. Apart from these abnormal and exceptional cases it may be found practicable to prepare a crop pest calendar* as a sort of rough forecast more or less on the lines of weather predictions. In spite of all the inevitable defects which such a calendar is bound to possess, it is believed that it might still serve some useful purpose in different ways. To the educated farmer, who is anxious to reduce the annual toll levied by insects on his crops, a knowledge of the probable time of appearance of important insect pests during a year will be a very valuable thing. For, in most cases of insect attacks, especially on field crops grown over extensive areas, preventive and precautionary methods go a great way in saving the situation. Therefore, it is apparent that such a knowledge will serve as a sort of warning to the farmer to be on the look-out for the pests and be prepared beforehand to take prompt measures the moment the pest makes its appearance or even just before it is expected to appear. To the Agricultural Entomologist this knowledge is much more. It gives him in addition. a clue to the seasonal habits of the different crop insects, their life cycles during the year, and a number of other interesting points in the biology of the various insects. It helps the official Entomologist of any Province not only to proceed to the different localities at the proper time to carry out investigations, but also to organize his campaigns against various pests sufficiently early and not be compelled to rush all

*The preparation of such pest calendars was discussed sometime ago between the writer and E. Ballard, Esq., B.A., F.E.S., Government Entomologist, Madras, and the author of this paper is indebted to Mr. Ballard for all encouragement in this direction

unprepared when the pest has already appeared and done some appreciable mischief. It will also help him to pre-arrange the work of his staff which might often be insufficient and not available in time if some sort of time-table is not chalked out for them corresponding to the periods of appearance of the different crop pests. A calendar of this sort is not without its use to outsiders. To an outside Entomoloist who wishes to study particular pests of the Province the calendar might indicate to him the approximate time of the year when he could arrange to visit the locality with advantage; we know of some cases in the past when experts have rushed from one corner of the country to another and returned disappointed. And as to its utility to an Insect Expert coming fresh into the country with absolutely no experience of the local conditions, no one, I think, will have any doubts.

The attempt made in this paper at the preparation of a Calendar for South India is entirely based on past experience with, however, no pretensions to any completeness or mathematical accuracy.

It is now fourteen years since work in Agricultural Entomology was started in Madras on a scientific basis. As one of the officers engaged in this work from its very inception in Madras—in fact, as one engaged in Entomological work from the very next year after the first official Entomologist was appointed for the Government of India—I have had opportunities to gather information and acquire a fair amount of personal knowledge of the various agricultural tracts of the province from an entomological point of view, apart of course, from suffering the various disadvantages incidental to the lot of a pioneer worker on a subject quite new to the country. Though ten or fifteen years is nothing compared to the long periods necessary to get any thorough experience of entomological conditions of any tract, I think I may lay claim to some experience, however limited, on the subject of insect pests of the Province.

In any agricultural tract all crop pests, at any rate insect pests, may be conveniently divided into three groups from the point of view of their seasonal occurrence. Under the first group might be included all those insects which appear on crops during regular seasons year after year causing sometimes less and sometimes serious damage. These are generally the major pests of the important staple food and industrial crops of different kinds. In Madras these constitute the important insect pests of crops like paddy, sorghum, millets, pulses, cotton, sugarcane, gingelly, groundnut, castor, tobacco, mango, etc.

The second group might be made to include certain insects which are generally of minor importance and occasionally found in small numbers but which only in certain years become sporadic serious local

pests; these appear on a variety of cultivated crops. As examples of these we have in Madras blister beetles of sorts, surface grasshoppers and locusts, surface weevils, climbing cutworms, tussock moths, slug caterpillars, etc.

The third group comprises those insects found all the year round without any marked seasonal variations in their appearance. These are generally found on perennial crops like palms, fruit trees, vegetables and garden shrubs; some of them also infest stored products and household materials. Familiar examples of this group are the palm beetles, white ants, rice weevil, meal worm moths, silver fish, etc.

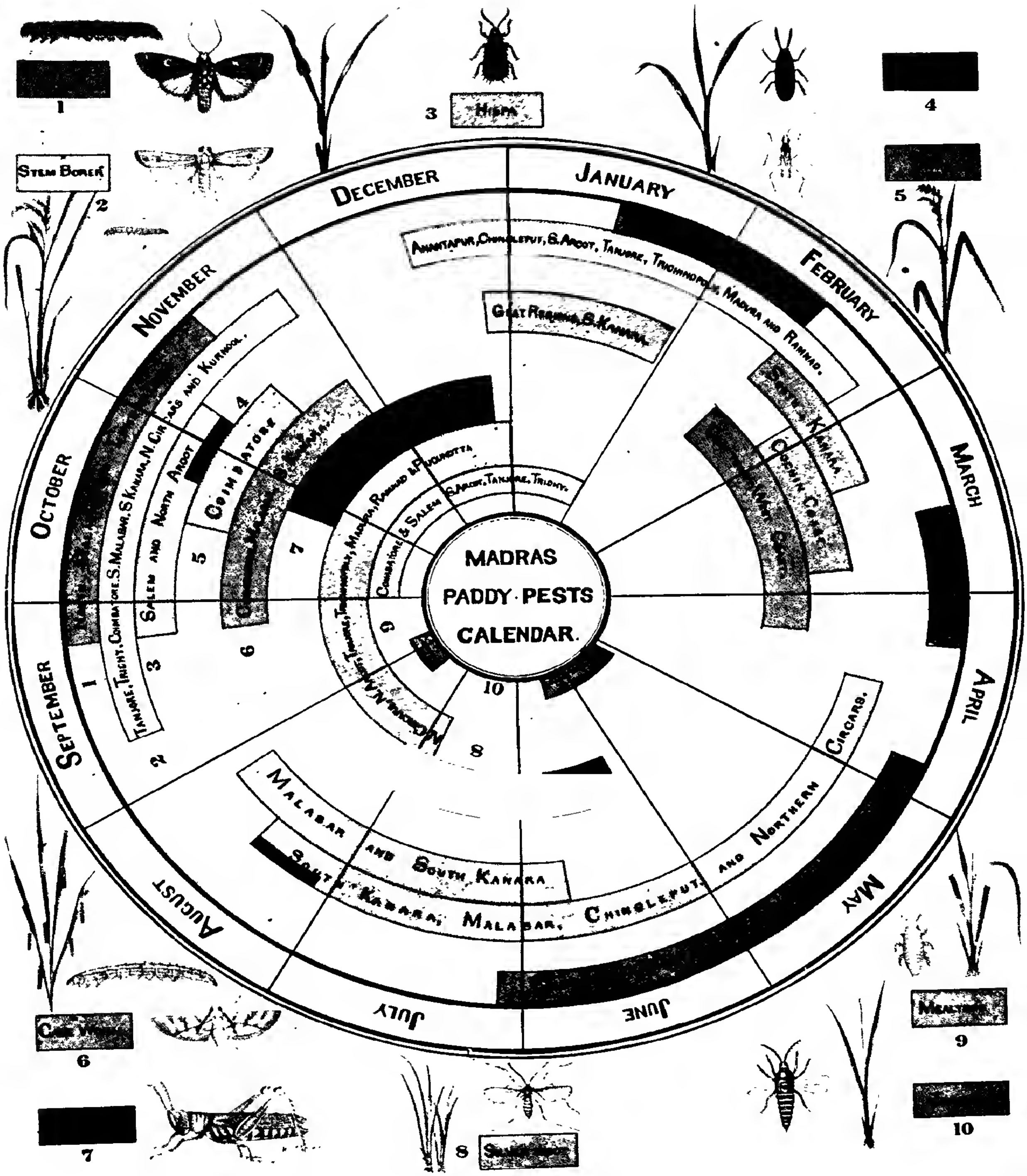
Of these three groups we may leave out of consideration in this paper the third group, as the insects under it do not exhibit any striking periodical or seasonal variations and as such are outside the pale of a regular calendar. Taking the first two groups we may consider the periodical activities of the important insects under each heading and see what place they occupy in the insect calendar.

In considering the periodicity of crop pests in any tract one has always to remember that the climatic and agricultural conditions of a particular area have a great deal to do with the appearance or absence of any pests. Unlike some of the other provinces of India we in the South (see map) have several distinct agricultural tracts each possessing distinct climatic and agricultural practices of its own; and naturally the crop seasons vary a good deal in the different tracts, the same crop having its own appropriate time in the year in the different regions. We have the West Coast area with its unfailing heavy rains (over 100 inches) chiefly during the South-west monsoon season from June to September; there are the Northern Circars including the big deltas which are irrigated by the rivers Godavari and Kistna; next the Carnatic Districts along the Coromandel Coast which get the greater part of their rainfall during the North-east monsoon season from October to January. Further down, we have the four southern districts of Tanjore, Madura, Ramnad and Tinnevelly with an average rainfall of not more than 33 inches for the tract, and which mostly depend on irrigation facilities for their important crops; and then we have the Deccan and southern tablelands with a scanty and capricious rainfall. This being the case one and the same insect affecting a particular crop appears in the different areas in different seasons. Keeping the above facts in view I have designed two or three diagrams wherein I have tried to show at a glance the periodical appearance of the important insect pests during any normal year.

To explain the seasonal distribution of the insects of the first group I have prepared two diagrams, a circular and tabular one. The former

is devoted to show the periodicity of the chief pests of the paddy crop alone, this being the most important staple food crop of the province and grown over a greater area than others. This diagram (Plate VII) represents nine concentric circles divided off into twelve parts to show the months of the year. The idea is to represent the periodical occurrence of about ten important paddy insects, which I have selected during the months of the year; each insect is allotted one of the nine circles and the time of its appearance shaded within its orbit. It may be stated at the outset that stray examples of almost all the common insects affecting paddy are generally found here and there throughout the year, but in every tract there is a particular season at which each insect often assumes pest proportions; and it is that particular period or periods of the year that I have attempted to indicate in the diagram. A casual glance at the diagram apparently shows that the paddy entomologist in Madras has work all through the year, but his busiest time appears to be from September on to February. Just a word or two to supplement the information that may be gathered from the diagram itself, may not be out of place here. The swarming caterpillar (*Spodoptera mauritia*) which is allotted the outermost circle in diagram No. 1 appears twice in the Northern Circars, *viz.*, at the beginning of each crop in June-July and January February, and often causes considerable damage to the nurseries. The next important tract where it is found is along the West Coast where it appears just before the South-west monsoon Rains and is equally destructive in certain years. During abnormal years the pest is reported from other tracts beyond the usual season. The paddy stem-borer (*Schoenobius bipunctifer*), No. 2 in diagram, is a regular visitor during the autumn and cold weather chiefly in the Northern Circars; it has, however, been very rarely noted to do such wholesale damage as the swarming caterpillar. It is occasionally bad during the summer months in the Ceded Districts. Within the past three or four years the disease called '*Yerra tegulu*' or red disease has been noted in the delta tracts of the Godavari and Kistna districts and has been mistaken to be the sole work of this insect. Recent investigations have shown that besides the stem-borer there are two other agencies at work, *viz.*, a leaf-spot fungus and another unknown disease associated with what at present appears like an eel worm*, both together doing far more harm than the paddy stem-borer insect. The leaf-mining beetle of paddy, popularly known as the "Rice Hispa" (*Hispa armigera*), No. 3, may be taken as the next important insect affecting paddy. During the South-west monsoon

* The eel-worm is being studied by Mr. Ballard, the Government Entomologist, Madras.



MADRAS PADDY PESTS CALENDAR.

months the insect is particularly bad in Malabar and South Kanara and later on in the irrigated central districts ; and in the Coromandel tracts it is found later. In South Kanara the pest is particularly bad and even does damage to the summer crop of paddy in February-March. In company with this beetle is often found the smooth greenish-blue beetle (*Leptispa pygmæa*), No. 4, which does appreciable damage in parts of Malabar from August to November. Next I have taken the Rice Bug (*Leptocorisa varicornis*), No. 5, the active paddy grain sucker. Though found all over South India periodical reports are received only from the West Coast tracts, especially from the villages along the Western Ghats. The case worm, *Nymphula depunctalis*, No. 6, is bad in Malabar and South Kanara during September to November and in the early summer months. The paddy grasshopper, *Hieroglyphus banian*, No. 7, like the rice bug, has a wide distribution in the province but assumes pest proportions only in particular tracts during certain seasons. In the West Coast, Tinnevelly and in the Mysore Ghat tracts it appears with the South-west monsoons and in the Circars during the later months. The Silver-shoot disease, *Kodu* or *Anaikombu*, *Pachydiplosis oryzæ*, No. 8, is bad in the Northern Circars from August to December during certain years. The paddy mealy-bug, the 'soorai' disease, *Pseudococcus sacchari*, No. 9, is found in the central districts during the cold weather. Thrips of paddy, which comes last among the paddy insects I have selected, *Bagnallia oryzæ*, No. 10, and which does some damage to very young paddy, is occasionally bad in Malabar, Chingleput and Coimbatore, especially when the usual expected showers are not received.

The second diagram, which I have prepared, shows the seasonal distribution of the important insect pests of other crops besides paddy and is a tabular one. Here I have only taken the most important of the numerous insects so far noted and especially those which display striking periodical activity. The most important of these insects which give trouble almost every year are the hairy caterpillars of dry crops, the castor semi-looper, the mango-hopper, caterpillars and plant lice of tobacco, the groundnut leaf-miner, the stem weevil, plant lice and boll worms of cotton, the gram caterpillar, the cholam ear-head bug, the gingelly caterpillar, the sann-hemp caterpillars and sugarcane borers. The hairy caterpillar (*Amsacta albistriga*) is particularly bad in the central districts, South Arcot and parts of the Ceded Districts from June on to October and attacks almost all dry and garden crops, such as *sorghum*, *cumbu*, groundnut, ragi, cotton, etc. The semi-looper (*Achæa janata*) is very destructive to castor in the Ceded Districts from October to December and later on in Salem and Coimbatore. The Mango Hoppers (chiefly

Idiocerus niveosparsus) are often very destructive to blossoms early in the year from January to March, chiefly in the important mango tracts of Salem, Bangalore, Chittur and Vizagapatam. The 'Plant Lice' pest on tobacco is an important one from December to April in Guntur, Coimbatore, Madura, Ramnad, Tanjore and South Kanara; the leaf caterpillar and stem-borer are often reported from the 'Lankas' in Godavari during the cold weather. The groundnut leafminer "*Surul puchi*" (*Stomopteryx nerteria*) causes appreciable damage to the ground nut crop, especially when the rain-fed crop is on the ground from September to November in the two Arcots and Trichinopoly. The cotton pests are chiefly noted in the Coimbatore and Tinnevelly tracts during the cotton season from October to May. The ear-head bug of cholam (*Calocoris angustatus*) is special to the Coimbatore and Bellary districts during June-July and sometimes in the cold weather also. The Slug caterpillar (*Parasa lepida*) which appears on a variety of plants like castor, mango, palms, etc., is chiefly noted during the months from October to January and in certain years causes serious damage. I do not think any special remarks are necessary for the other insects and their distribution may be gathered from the diagram itself.

Coming to the second group of pests which, as I said before, includes insects of minor importance occasionally found in small numbers, but which appear as sporadic local pests only in certain years, I have added another diagram. Such insects are few in number and during normal seasons they are practically of no importance at all. On our knowledge and experience of insect pests in South India, about ten insects may be brought under this head as displaying the remarkable habit of abnormally multiplying and appearing suddenly only in certain years. The climbing cut-worm of paddy (*Cirphis albistigma*) may be taken as a good example. During some years when the rainfall is unusually heavy and the fields are flooded during the North-east monsoon months on the Coromandel Coast, this pest begins to appear and often assumes serious proportions during January-February, thousands of caterpillars being found cutting down the ripening ear-heads. For three or four years in succession from 1912 there was the locust plague in the Ceded districts during the months August-November caused by the Deccan grasshopper (*Colemania sphenarioides*) attacking all dry cereals of the tract. Fortunately, for the past two or three years, it has not been reported serious. Of the others, the chief are the black hairy caterpillar (*Amsacta lactinea*) on *ragi* and *cholam* in Coimbatore and Salem during August-September, the Surface weevil (*Atactogaster finitimus*) found on young cotton in Tinnevelly during November, Blister beetles of sorts (*Lytta, Epicauta,* spp.) attacking *cumbu, cholam,* etc., in October-November, the Hawk

moth caterpillar (*Herse convolvuli*) on green gram in the Circars during the cold weather, the green plant bug (*Nezara viridula*) on *cumbu* in Tinnevelly in November-December, grasshoppers (*Catantops* sp.) on cotton in Ramnad in December-January, surface grasshoppers (*Aiolopus* spp.) on cereals in Coimbatore and Ramnad in August-September and Tussock moth caterpillars (*Euproctis*, *Orgyia*, spp.) on red gram and castor during the cold weather.

I have thus tried to give an idea, however incomplete, of the periodical occurrences of the most important insect pests of South India by dividing them into three more or less convenient groups, and I have attempted to convey as much information as possible in the diagrams which illustrate this paper. I believe, as our knowledge and experience increase, it might be possible to amend this calendar in the light of new observations, and make it far more accurate and complete than it is at present. Till then I venture to believe that this calendar might serve some useful purpose.

In conclusion, I am of opinion that if such calendars are prepared for the different provinces they will be found not only useful in themselves, but, taken as a whole, will give one a fund of information on the distribution, seasonal variation and food habits of some of the important crop-pests which are common to all tracts of the Indian Empire.

7.—SOME NOTES ON ATTEMPTS TO PRODUCE IMMUNITY FROM INSECT ATTACK ON TEA.

By E. A. ANDREWS, B.A., *Entomologist to the Indian Tea Association.*

Mention has been made, at previous Meetings, of the correlations which have been found to exist, in the case of tea, between the nature of the environment and the degree of liability to attack by insect pests, and by *Helopeltis theivora,* the tea mosquito, in particular. The apparent importance of the relative amounts of potash and phosphoric acid, present in the soil in an available form, and of the relative amounts of the same substances in the leaves before and after *Helopeltis* attack has also been discussed and accounts have been given of various manuring experiments carried out with a view to increasing the relative proportion of available potash in the soil as compared with phosphoric acid, in the hope that the plants would thereby absorb a larger proportion of potash, and acquire an increased resistance to attack by the pest.

This work has been carried further since the last Meeting, both in the direction of accumulating evidence to corroborate our ideas and of carrying out experiments designed to increase the resistance of the plants to attack by the insect.

We commence with the fact, founded on extensive observation and experience, that comparative immunity from *Helopeltis* attack not only can, but does, occur in nature. In our attempts to produce immunity, we are attempting to discover and reproduce the conditions under which this immunity occurs in nature. The conditions affecting the question are considerably complicated, but would appear to be bound up with the relative proportions of potash and phosphoric acid taken up from the soil by the plant. This is controlled, not merely by a difference in the type of soil, but by difference in the physical and chemical condition of the same soil. Cases have been investigated in which the same soil, under different treatment with regard to cultivation, etc., has produced bushes which show differences in degree of liability to attack by *Helopeltis*. These investigations have so far shown very little, but the importance of the potash phosphoric acid ratio has been emphasized by the results of analysis of leaf plucked from bushes which were throwing off the attack of the pest. Cases were observed, in districts as remote as Sylhet and the Duars, in which bushes, which had been absolutely

shut up by the pest, were growing through the attack without being *touched. Leaf was plucked from these bushes and analysed, when it* was found, in *all* cases, *that the ratio of potash to phosphoric acid in* the leaf was 4 to 1. Since the normal ratio is 2 to 1, it is plain that the throwing off of the pest is connected with a distinct increase in the potash in the leaf as compared with the phosphoric acid, which corroborates previous ideas.

The state of affairs, then, before the carrying out of the experiments about to be referred to, was that there was a considerable amount of evidence to show that an increase in the ratio of potash to phosphoric acid in the leaf produced increased resistance to *Helopeltis* attack and that experiments designed to increase that ratio by the addition of potash to the soil had given results which, though positive in a few cases, were contradictory to others. The obvious experiment to perform was that of direct injection of the bushes with potash, so as to eliminate the disturbing influence of the soil factors. This had been tried, but unsuccessfully. At the last meeting I discussed this work with Dr. Gough and he made various suggestions with regard to the injection of the bushes by way of the roots. After a certain amount of experiment I found that if a number of the feeding roots were placed into a solution of a soluble salt of potash this solution was taken up, and in 1919 we were successful, on one garden, in causing bushes which were black with "mosquito blight" to throw off the attack of the pest and give strong clean flushes to the end of the season. During the last season the experiments were repeated on a larger scale, in all the affected districts, and on different types of soil, more than eleven hundred bushes being treated in Assam, Cachar, Sylhet, and the Duars. It is to be regretted that circumstances compelled me to postpone my final tour of inspection of the experiments until January, with the result that I have not yet had time to work out the results as thoroughly as I wish. Two significant points, however, stand out. The first is that the only substance which has produced increased resistance to attack is potash, the second is, that attempts to increase the liability to attack appear to have failed. The percentage of experiments which worked satisfactorily was small, owing partly to the fact that some of the substances used were unsuitable, and partly to lack of experience of work of this kind. The most satisfactory strength of solution to use was found to be a half to one per cent. The method of carrying out of the experiment was as follows: A small root or a bunch of small roots was exposed, freed from soil, and immersed in a cigarette tin containing the solution. The tin was then fixed firmly in position by ramming the soil round it, covered with strong paper to prevent soil from falling into it, and the excavated soil put carefully

back over it. It was essential that the bushes treated should receive the usual cultivation, etc., so that a number of the tins were hoed out during the season. The tins had this disadvantage, that wherever the roots came into contact with the tin the iron of the tin came into the reaction, and the roots became covered with a deposit of red oxide of iron. Vessels made of glazed earthernware would have been better, but they, again, possess the disadvantage of being fragile. In arranging the roots in such tins care must be taken that the roots are not in contact with the tins at any point, as they will be killed off by this deposition of iron oxide. It was further found that care should be taken that the roots do not go too far down into the solution, as this latter tends to be more concentrated at the bottom than at the top, and may be so strong as to kill the root off. The roots chosen for immersion in the solutions should be the fine feeder roots. Thicker roots do not grow successfully in these solutions. A factor which affected the growth of the roots was the degree of acidity or alkalinity of the solution used. Solutions which were very definitely acid or alkaline did not allow of root growth, but in cases where this solution was neutral, or just faintly acid, a luxuriant growth of new roots was obtained.

From one or other, or from different combinations of the above causes, many of the experiments were failures, and no root-growth occurred inside the tins. In such cases all the solution was left, and none of it absorbed, the few exceptions found being explained by soil having fallen into the tin, or to its having been struck by a hoe, etc. In all cases where root-growth occurred in the tins all, or nearly all, of the solution was taken up.

The successful experiments, however, confirm the results of those carried out in 1919, and show that potash when taken up by the bush *viâ* the roots, results in a decreased liability to attack, which is not of the same degree under different sets of conditions. The relations between the result and the environmental conditions I have not yet had the opportunity to work out. The attempts to increase liability to attack by the use of phosphates were fruitless, as the acidity of the phosphoric solutions used inhibited root growth.

Much yet remains to be done on these lines, but we do know now that bushes can be made resistant to attack by *Helopeltis*. This resistance has been brought about by experiments designed to influence the composition of the leaf with regard to the proportion of the various constituents already present in the leaf, and since our analytical results show that this can vary within considerable limits under the conditions obtaining in tea, there would appear to be ample grounds for believing

that subsequent research will enable us to control the pest on a larger scale by treatment of the bushes.

It was quite a new line of work which was taken up by Mr. Andrews and I congratulate him on the success that he has achieved in the course of his investigations of this important pest.

In connection with this interesting and instructive paper, I may mention that we tried to inject essential oils into plants. The *modus operandi* was very simple. We made an incision into the bark and connected the incised portion with a funnel containing the oil by means of a rubber tubing, the funnel being placed at a higher level. May I know from the lecturer if we were proceeding on right lines? The experiment was in connection with our work on Chemotropism and it was an attempt to permeate a plant with a scented substance.

I should first like to know how high the funnel was from the plant and at what distance from the root the incision was made.

The funnel was placed about $1\frac{1}{2}$ feet higher than the plant and the incision was made at a distance of about 2 feet from the root.

It is only possible to get plants to take up solutions.

8.—REPORT OF CAMPAIGN AGAINST *SPODOPTERA MAURITIA*, BOISD., (*NOCTUIDÆ*), IN MALABAR.

(Plates VIII—XII.)

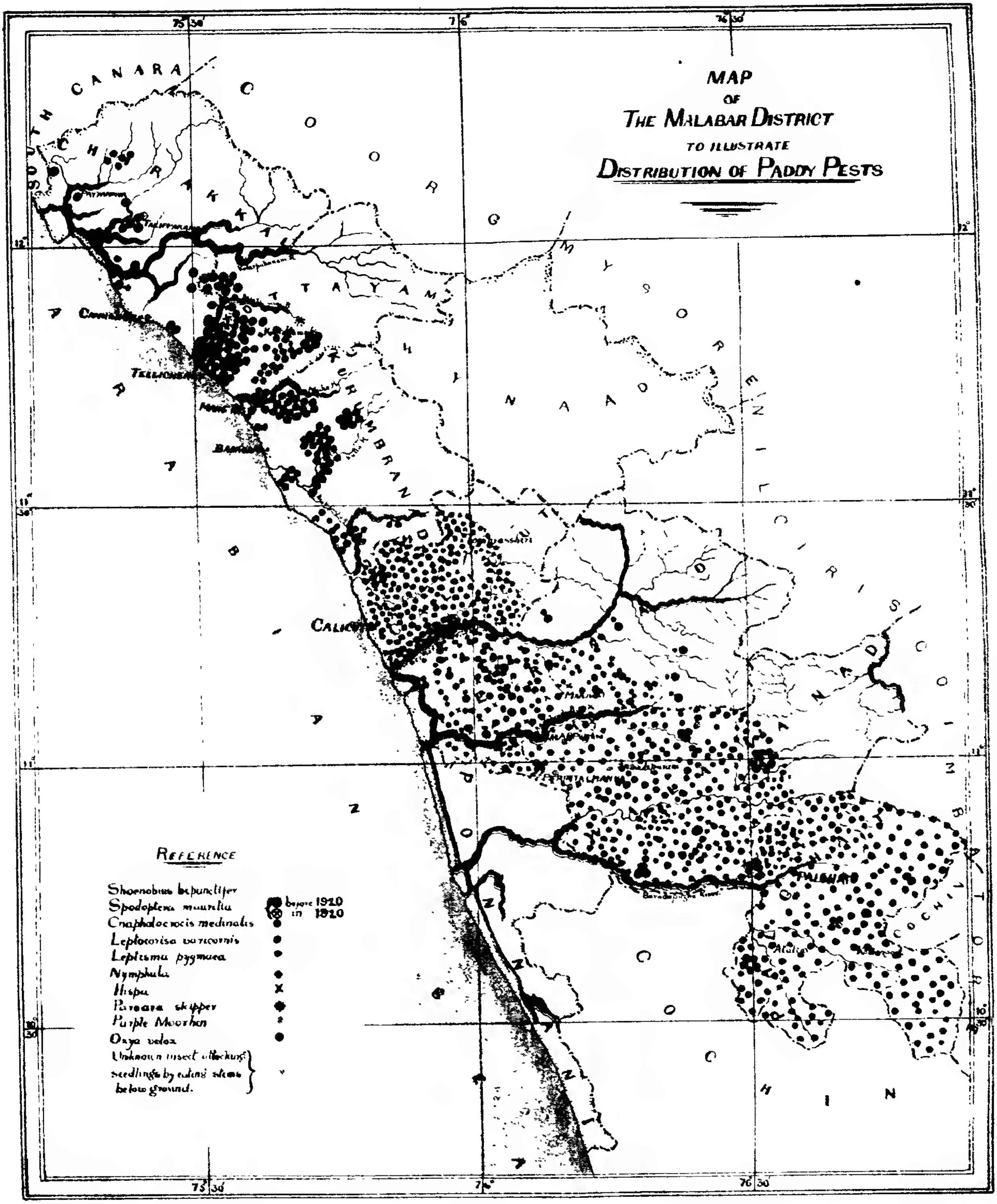
By E. BALLARD, B.A., F.E.S., *Government Entomologist, Madras.*

Spodoptera mauritia, Boisd., is one of the most serious pests of paddy* in Malabar. Its appearances are erratic but always fatal unless timely precautions are taken in dealing with it. In some cases during a heavy attack the caterpillars are in such numbers as to cover the roads and *bands* and they even invade the gardens. The main fact of its lifehistory, egg and pupal periods and so forth are well known, but there is a very large number of questions which still remain unanswered. With a little organization its control when it appears in pest conditions is comparatively easy, but unfortunately it is seldom noticed by the *raiyats* until the larvæ are more than half grown by which time the damage done is serious, often necessitating either the resowing of the crop or the purchase of seedlings from unattacked areas. Up to the present year it had been the custom to await reports of the appearance of the pest from Tahsildars or *raiyats* and then to send an officer to demonstrate control measures. Although information was often (and in 1919 almost invariably) given by wire, a great deal of damage had generally been done before the officer could get to the spot. Leaflets explaining the methods of controlling the insect and its habits had been issued to the revenue authorities but it is only in very exceptional cases that these leaflets ever reach the *raiyat*. They either disappear into the Taluq offices or else remain with the village officials carefully filed. My return to India in May 1919 coincided with a very fierce and widely spread *Spodoptera* attack, but little could be done to deal with it at that time. It was decided therefore to be thoroughly prepared for the pest this year (1920) and for this purpose a programme of propaganda and extension lectures was drawn up and put into operation.

Before giving an account of the plan of campaign and the extent to which we were able to conduct it "according to plan" it would be as well to give some short account of the lifehistory and habits of *Spodopetera mauritia* itself. (Plate IX.)

"The eggs are deposited usually on the under surface of blades of grass or paddy in batches covered with buff-covered hairs derived from

* Oryza sativa.


MAP OF THE MALABAR DISTRICT TO ILLUSTRATE DISTRIBUTION OF PADDY PESTS
SOUTH CANARA
CHIRAKKAL
COORG
KOTTAYAM
MYSORE
KURUMBRANAD
WYNAAD
NILGIRIS
ARABIAN SEA
CALICUT
ERNAD
PONNANI
WALLUVANAD
PALGHAT
TELLICHERRY
CANNANORE
COCHIN
COIMBATORE
REFERENCE
Shoenobius bipunctifer
Spodoptera mauritia
before 1920
in 1920
Cnaphalocrocis medinalis
Leptocorisa varicornis
Leptisma pygmaea
Nymphula
Hispa
Parnara skipper
Purple Moorhen
Oxya velox
Unknown insect attacking seedlings by eating stems below ground.

SPODOPTERA MAURITIA.

EXPLANATION OF PLATE IX.

Spodoptera mauritia.

Fig. 1. Egg-mass as laid on paddy-leaf.
Fig. 2. A single egg magnified.
Fig. 3. Young larva in characteristic attitude
Figs. 4, 5, 6, 7, 8. Larvæ in various stages of growth.
Fig. 9. Pupa.
Figs. 10, 11, 12. Moths.

(The lines alongside the figures show the natural sizes.)

the body of the female moth. The full-grown caterpillar is 35-40 mm. long, cylindrical, paler or darker green above, greenish yellow beneath, with a reddish stripe along the sides at the junction of the two lines; along the side there is sometimes a broad pale stripe edged above by black lunules on each segment; when touched the caterpillar curls up until the head and tail are nearly touching in a characteristic manner.

"When full fed it pupates in the soil, turning into a brownish pupa, from which the moth emerges in ten days."*

The larva is essentially a night feeder, but in districts which are permanently under water it feeds by day, or remains clinging to the blades of the paddy; and it is in such situations that its control is most easily effected.

The appearance of an attacked paddy plot is very characteristic and gives the impression of having been grazed by cattle; in fact, the writer has more than once gone to a seed bed to look for *Spodoptera* in tracts where it was in pest conditions only to find that stray cattle were responsible for the seedlings in that particular plot being eaten down, although at a short distance a *Spodoptera*-attacked plot bore the same aspect.

So far as our experience in Malabar goes, it would seem that in that district there is only one generation in the year, although it is possible that in one or two places, and then only exceptionally, a few moths may come out a month earlier than is usual.

The first and only emergence appears to take place in May† and it is this generation which is the pest generation. It was believed that there was a preliminary small emergence in March or April, but all searches for moths or caterpillars were fruitless and it is very doubtful whether any generation precedes the one in May. Except in a very few places there would be no food for the larvæ before this time as the whole country is dried up. By the beginning of May most of the paddy has been sown. In Malabar this paddy starts as a dry crop and the *raiyat* is dependent on the South-west monsoon for it to reach maturity. There is no tank irrigation, and most of the paddy is either sown broad-cast or in lines behind a plough. Transplantation, where it occurs, is done after the monsoon has burst and the fields are flooded. Once the monsoon has burst and burst well, there is no more trouble from *Spodoptera* as the fields fill up so rapidly and the rain descends with such force that the larvæ are drowned and carried away. They may also be driven to the tops of the paddy blades and devoured by birds. If the monsoon is late,

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* Fletcher, *Some South Indian Insects*, p. 378.

† Unless the contrary is stated all remarks on the habits of *Spodoptera mauritia* only apply to Malabar district.

therefore, the damage done by *Spodoptera* is liable to be greater than if the monsoon is either weak or early.

Another factor which appears to have some effect is the occurrence or otherwise of the early " sowing rains " which precede the real monsoon. This year these were almost entirely absent and it is likely that the dry conditions prevailing caused the non-appearance of *Spodoptera*.

It has been stated above that one can never foretell the place which will be attacked in any particular year. Judging from reports and petitions received in this office and from personal inquiry from *raiyats* it hardly ever turns up two years in the same place. Sometimes as much as seven or eight years may elapse between attacks. Other *raiyats* claimed to remember an attack thirty years ago and none since. One cannot therefore forecast the point against which an assault will be delivered and the only preliminary precaution which can be taken is to spread a knowledge of the lifehistory of the insect and means of controlling it to as many *raiyats* as possible, so that all will have at least the chance of being warned and profiting by the warning or send for assistance in time.

The Plan. The plan of campaign consisted of three parts :—

(1) This was a publicity and press campaign ; articles were to be written in the local vernacular papers, and interviews given to correspondents of these papers.

(2) In all prominent places, bazaars, toddy-shops, road-side trees, Railways Stations, Railway carriages, etc., posters were to be stuck up. These posters were of two kinds and were to accompany one another. The first poster was a large coloured one prepared under my direction by my Head Artist. The second was to be smaller and explanatory of the first.

By the times these posters had been pasted all over the seven taluqs selected for the campaign, it was calculated that the lecturers would have got to work.

One lecturer was sent into each *taluq* with orders to collect as many *raiyats* in each *amsam* as possible and give a lecture on *Spodoptera mauritia* and a simple account of its lifehistory. He was to encourage *raiyats* to ask questions and to explain to them the habits of any other paddy pests of which they might complain.

At the end of the lecturing tour, which was to begin on 1st March and finish on 15th May, each lecturing officer was to return to *taluq* headquarters and there await reports of the appearance of the pest from *raiyats* or village officers. At all lectures *raiyats* were to be told where the officer in charge of their *taluq* was to be found and that any call for his assistance would be responded to at once.

(3) The final phase of the campaign was to consist of a prompt reply to all demands for aid, and a personal demonstration of the methods which had been advised.

The Revenue Authorities were asked to help ; the Educational Department was provided with lantern slides and a short account of the pest so that lectures could be given in schools. School-masters were to be instructed to get into touch with the officer lecturing in the *taluq* in which his school was situated so that should the pest appear school-children could be shown it in the fields and the opportunity given of at least one piece of nature study. Lastly the co-operative societies which were very strong in one *taluq** were to be asked to help to gather *raiyats* together and to read leaflets and posters.

The control methods which were advocated and which have given satisfactory results in the past were as follows :—

(1) On the appearance of the caterpillar the first thing to do is to isolate the attacked area by digging steep-sided trenches around it. The caterpillars as they migrate fall into these trenches and are unable to climb out. They can then be easily crushed and killed. In the meantime the caterpillars in the attacked areas can be collected in winnowing fans and bags and destroyed.

(2) Where water is available the attacked areas can be flooded and the caterpillars driven to the tops of the blades of paddy from which they can be either knocked off and drowned by dragging a rope or bamboo across, or they can be collected by hand. In this case also they are much exposed to the attacks of birds, who are always of great assistance.

If the rope method is used, water should be drained off after the caterpillars have been knocked from the plants as, if fairly old, they can climb up the stems again. Young caterpillars are easily drowned.

(3) After an attack by *Spodoptera*, *bands* should be scraped and pupæ exposed or destroyed.

(4) It is the custom in some parts of Malabar to scatter rice on the *bands* when *Spodoptera* has appeared, in order to attract the birds.

(5) Before there is any water in the fields a close watch is to be kept on broad-cast paddy and on seed-beds.

(6) Provision of perches for birds in the fields.

(7) Isolation of seed beds by trenches.

This was the ideal. How far the realization fell short of it will now be shown.

With the exception of one *taluq* (Calicut) all lectures began according to programme on the 1st of March. The preliminary press adver-

* Walluvanad.

tising had been well done and in theory knowledge that the lectures were going to be held should have been fairly widespread. It was hoped that some discussion would have been excited and that some *raiyats* at least would be anxious to turn up to the lectures and find out what they were all about.

In actual practice the advance advertising was a failure. Little, if any, advance information had filtered down to the actual cultivators and those who had seen the newspapers did not appear to have attached any serious meaning to the enclosed slips.

Some *raiyats* had heard that an officer was coming to talk to them but complained that they had so often been told that some official or other was coming to their village who, after preparation to receive him, had not come, and that they had taken no notice of any leaflet or poster that they had seen.

Again, owing to a variety of causes the coloured posters did not arrive until it was too late to use them. Printed posters had been issued to the *Tahsildars* who had forwarded a few to *Adhikaris** who had taken no action. In one *taluq* only, where the co-operative societies were called in to aid us, had the posters been stuck up in prominent places as had been previously arranged.

What actually happened was that arrangements were made with the *Adhikari* the day previous to any lecture and he was responsible for gathering his *raiyats* at the chosen spot. These arrangements had usually to be made in person by the lecturer. *Adhikaris* differed very much in the amount of enthusiasm which they showed.

Some meetings were very well attended, others consisted of two or three *raiyats* only. Taking the lecturing part of the programme as a whole, the size of the audiences was disappointing†. I had hoped to provide each lecturer with a magic lantern but only four could be procured, one of which was kindly lent by the Publicity Bureau, and these generally gathered better crowds than a lecture which was not illustrated by lantern slides. The interest displayed in the lectures themselves varied very much with the part of the district in which they were given. In some parts also the knowledge of the pests was quite good, derived not from leaflets or pamphlets but from observation. The poorest audiences from point of view of numbers, were obtained in Calicut and Ernad *taluqs*. The latter *taluq* is the greatest Moplah stronghold and most *raiyats* refused to be convinced that their usual method of dealing with insect pests, namely, of paying Rs. 100 to the local priest and getting

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*Amsam (village) head-man.
† Number varied from 5 to 300.

from him a flag to wave over the fields, was not infinitely better than anything suggested to them by an officer who was not one of the revenue officers and therefore of no account. In Calicut *taluq* the usual apathy which is so difficult to fight against was responsible for the poor attendance.

The "*Paramba*" system in Malabar, so peculiar to that district, always make a *raiyats*' meeting difficult to get together. There are practically no villages in the usually accepted sense of the word. Dwellings are very scattered and one has to depend on the big landholders to get their tenants together. If the landlord is sympathetic and willing, a good number of *raiyats* can always be obtained ; if he is apathetic and takes no trouble, as sometimes happened, then it is very difficult to get at the actual cultivator.

Another factor which contributed to the difficulty of collecting audiences was the suspicion on the part of the *raiyats* that the meetings were a ruse to obtain war loan, or contribute to the war fund. Others said that, although on the face of things it was good of Government to send officers to warn them about pests and help them to save their crops they were afraid that they would be charged heavily for any demonstration or help which was given. Others again who were behindhand with their dues were afraid that they would be put to shame before their neighbours by being asked to pay on the spot at the meeting.

The magic lantern, as already stated, always proved an attraction and a cinematograph would have been better still.

The final part of the plan of the campaign could only be put to the test in one case. An exceptionally heavy monsoon which burst with great violence was apparently the cause of *S. mauritia* being in pest conditions in only one tract. In this particular case the *Adhikari* unlike the others in that *taluq* had been very slack and had taken no interest either in getting *raiyats* together or seeing that the lecturer had any assistance. However, he did notice, or the *raiyats* noticed, that the pest had arrived and sent in to *taluq* head-quarters according to the instructions received. This report reached *taluq* head-quarters on 10th June. The lecturing officer in charge of that *taluq*, although he was constantly in touch with the *taluq* office, was not told of the report until seven days later. In seven days *Spodoptera* can do a great deal of damage. In spite of these delays the pest was checked by trenching off the attacked areas and collecting the caterpillars in winnowing fans, and one-third of the seed-beds were saved. This was the only report received and all lecturers were recalled by the end of June.

The time and money spent on this campaign were not wholly wasted. The existence of the Agricultural Department was brought to the know-

ledge of a large number of the people who formerly knew nothing about it and, whether from innate courtesy or from real feeling, there were cases where gratitude was expressed that Government had taken the trouble to make all these arrangements for their benefit. One *raiyat* at least stated that he had formerly looked on Government simply as a tax-collector but had now been most happily proved to be wrong.

The Staff.

The staff used in this campaign consisted of three Assistants, three Sub-assistants from my section and two Assistant Farm Managers sent to me by the District Staff. When first drawing up the scheme for the campaign I had hoped to have a much larger number of men at my command. Things, however, turned out otherwise.

These lecturers armed with four magic lanterns actually addressed meetings of various sizes in 570 *Amsams*, or villages, taking two-and-a-half months to complete the work.

Three men had to be withdrawn as casualties on account of fever or accident. One of these was also called away for other work in another part of the Presidency and one more had to be withdrawn to head-quarters as the new term at the College was about to begin.

In conclusion, I should like to emphasize the good results which must follow from a campaign of this kind. Not only did it give a unique opportunity for collecting information about the distribution of various paddy pests, but it supplied the means of getting into touch with the people. Hundreds of *raiyats* who had never heard of the Agricultural Department now know of its existence, and have been given proof that Government is not merely a tax-gatherer.*

Concentration of the whole energies of the section on work on such a large scale naturally put a great strain on our resources and involved the refusal of help in many isolated cases in other parts of the Presidency. But it cannot be too strongly insisted on that once a campaign of this kind is started, it should be carried through to the end. Sickness and other casualties cannot always be avoided but men should not be withdrawn for other work. The principle of the concentration of overwhelming force at a particular point rather than the dissipation of energies against many isolated objectives should be avoided as much in pest campaigns as in war. Although we had only one opportunity of testing the final phase of the campaign and that only in the most unfavourable circumstances, I think it is justifiable to claim that, had the *Spodoptera* attack this year been as severe as it was last year and in

* This must not be construed into a criticism of the local Agricultural staff who being few in number cannot cover the whole of a big district such as Malabar.

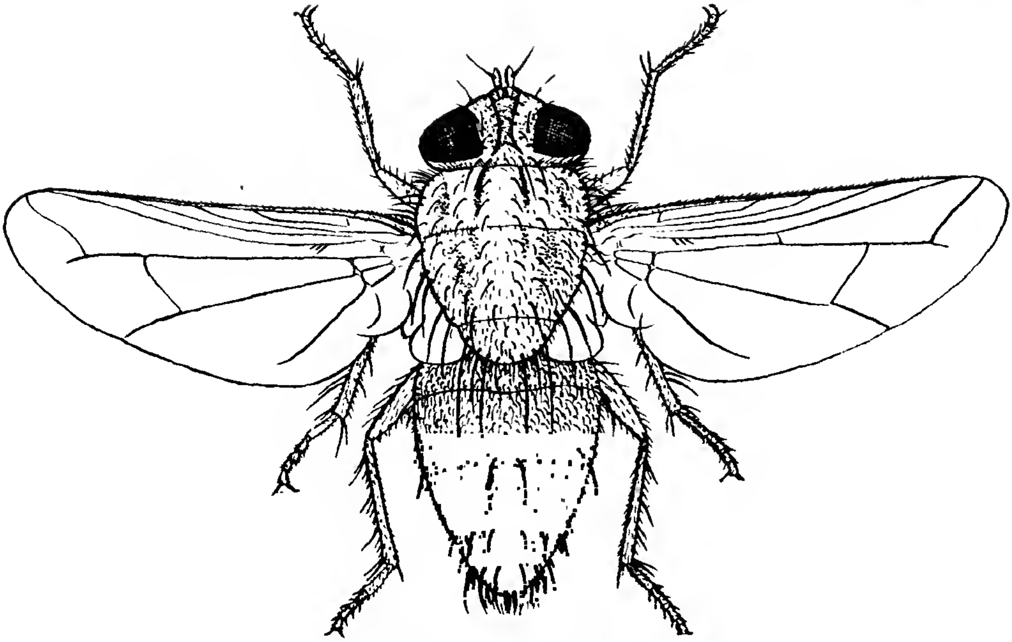


Fig. 1.—*Cyphocera varia*, F. (×6).

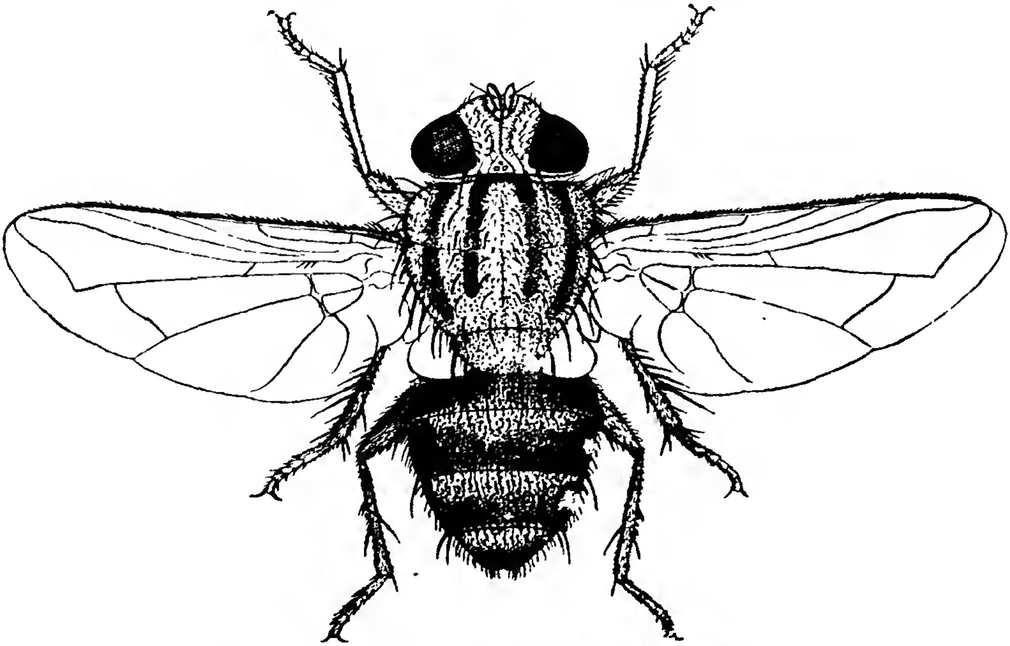


Fig. 2.—*Pseudogonia cinerascens*, Rond. (×7).

previous years, hundreds of acres of paddy would have been saved which last year were lost.

I wish to express my gratitude to the Revenue Officials, School-masters, the Publicity Bureau, and the Co-operative Societies, and especially to the Honorary Assistant Registrar and to all land-owners and village officers who gave their help.

Summary of Publicity Campaign and Lessons Learnt Therefrom.

1. In all over 570 *amsams* were visited.
2. The newspaper advertisement was not attended with the success deserved by the manner in which it was done.
3. It would be better on another occasion to advertise the lectures by coloured posters and leaflets only a day or two before the lecture was given to any particular *amsam* or village.
4. A cinematograph camera would be invaluable; not only could control methods be shown actually being put into operation, but by showing one or two films of general interest large audiences could easily be collected.
5. All posting, pasting, etc., should be done by the Agricultural Department themselves and not left to Revenue Officers who already have a multiplicity of duties.
6. The present practice of distribution of leaflets, at least of those dealing with crop pests, is practically useless without lectures and, whenever possible, demonstrations at the same time.
7. Shortage of staff and the difficulty of a country like the Madras Presidency where four or five different languages are spoken makes the task of providing enough lecturers by no means easy for a campaign on such a large scale.
8. With an insect like *Spodoptera mauritia,* whose appearance at any particular spot cannot be depended on, a vary large part of the district must be covered so that all may be warned.
9. The peculiar conditions of Malabar made the collection of audiences difficult, but on the whole a good deal of interest was shown when once the lecturer began, although this naturally depended largely on the lecturer. In some cases this interest almost amounted to enthusiasm.

Appendix I.

S. mauritia is parasitized by the following Tachinidæ which have been identified by Dr. Villeneuve for the Imperial Bureau of Entomology.

1. *Actia ægyptia,* var, Villen. (Plate XI).
2. *Pseudogonia cinerascens,* Rond. (Plate X, lower figure).

3. *Tachina fallax*, Meig. (Plate XII, lower figure).
4. *Sturmia bimaculata*, Hartig. (Plate XII, upper figure).
5. *Cyphocera varia*, F. (Plate X, upper figure).
6. A species of *Chelonus* (Braconidæ).

APPENDIX II.

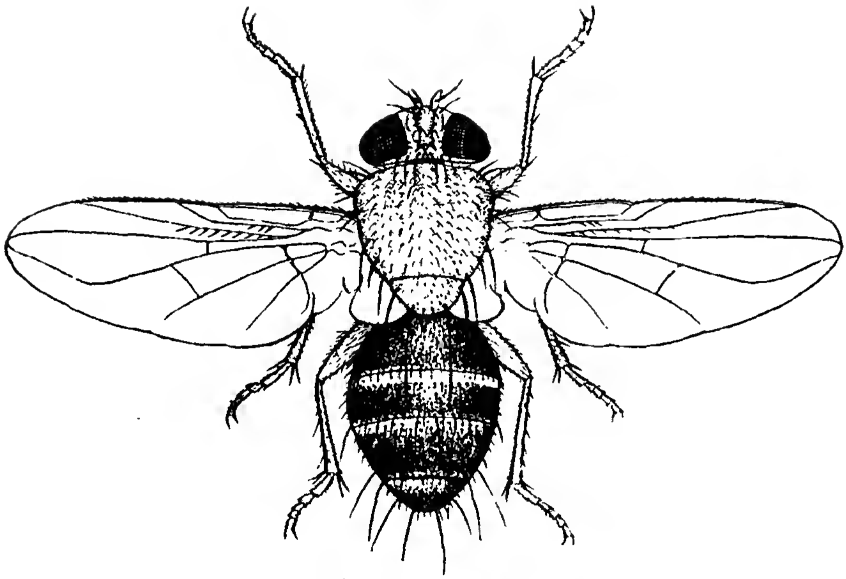
List of birds known to feed on Spodoptera mauritia.

1. Common Crow.—*Corvus splendens.*
2. Jungle crow.—*Corvus macrorhynchus.*
3. Cattle egret.—*Bubulcus coromandus.*
4. Paddy bird.—*Ardeola grayi.*
5. White-breasted water-hen.—*Amaurovius phœnicocurus.*
6. Common Mynah.—*Acridotheres tristis.*

This matter interests me as far as it concerns the spiders. The species sent me by Mr. Ballard is not a true colonial spider, although it lives in groups, but is a *Lycosid.* Subsequently Mr. Ballard sent me live specimens which escaped in transit but their webbings were like those of *Stegodyphus,* a true colonial spider which makes webs on bushes. Members of the Lycosid genus *Hippasa* usually live in holes or crevices on branches or roots of trees and make a big white sheet of web out of which leads a tunnel in which males and females are often found. How they feed I do not know. It is quite likely that a spider of this kind, if it took to eating caterpillars, would be quite useful, in case its webbing is not too heavy to interfere with the growth of the paddy crop, and if the spider goes night-hunting. If *Stegodyphus* was used, the very dense web would damage the paddy. This latter spider never leaves its web, and an insect has to fly into the web before it is caught. A further investigation would be very interesting. While at the Science Congress at Nagpur last year, a School-master told me that *Stegodyphus* was used in some parts of India for catching flies and mosquitos in houses. The point about *Hippasa* is, whether it ever leaves its web.

I think the effect of removing a *Stegodyphus* nest from a bush to a paddy field, which is an unsuitable locality for the spider, would result in all the spiders separating and walking about in search of a suitable place, leaving trails of silk. The colony would die out but the trails will catch insects.

I have listened to this paper with very great interest. Our difficulties are similar in Ceylon. It is very hard to get any immediate information about an attack. In the only case of which I have personal knowledge, the information was not received till the attack had been in progress for two weeks. It was in a small isolated area where it could have been



Actia ægyptia, **Villen (×12).**

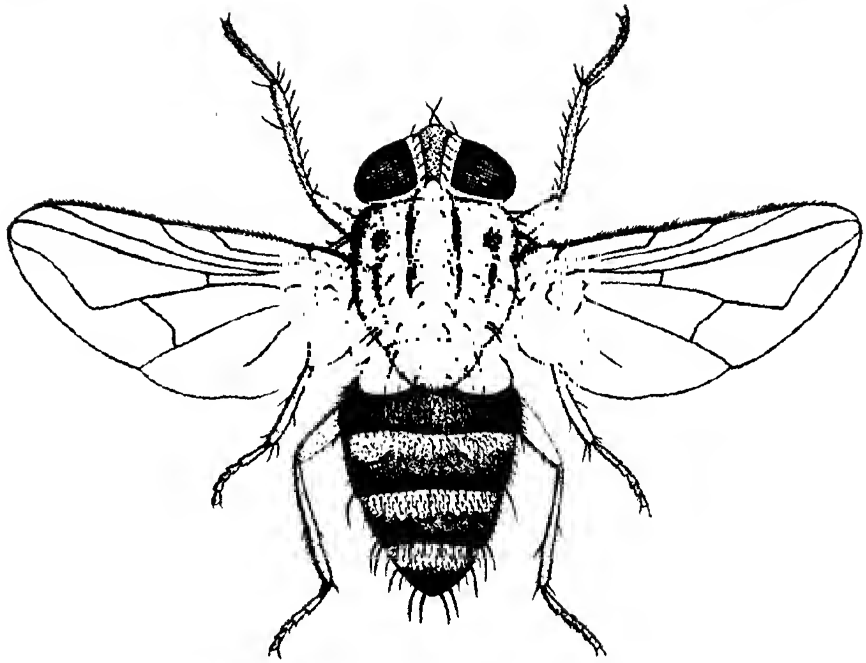


Fig. 1.—*Sturmia bimaculata*, Hartig (×10).

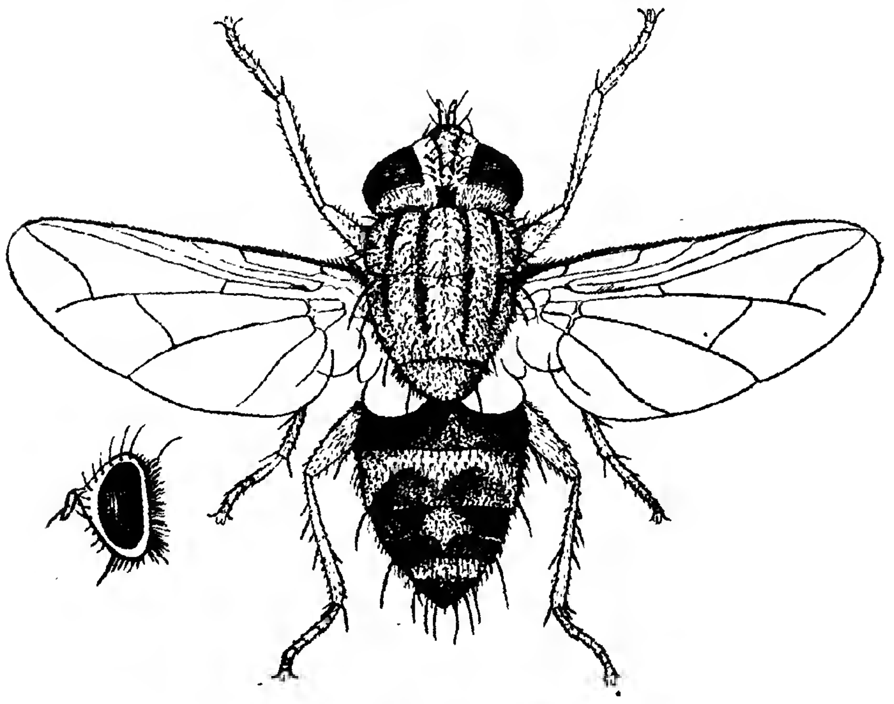


Fig. 2.—*Tachina fallax*, Meig. ♂ (×9).

easily stamped out, if tackled at once. But as it was, the cultivators took no hint from the first signs when the grass turned brown on the *bands* and did not connect this with the invasion in the field. Thinking that the larvæ are carried into the fields with the irrigation water, the cultivators cut it off with the result that the plants were eaten close to the ground and were completely destroyed. The utter lack of co-operation amongst the cultivators was noticeable. No help was given to the man whose plot was first attacked. Crows and other enemies are very useful, but only in the later stages of the attack. In Ceylon also rice is thrown down to attract birds.

At the end of the attack a Braconid parasite makes its appearance.

Outbreaks in Ceylon occur at the end of the year in November or December, especially if the South-West monsoon is a failure. It is impossible to say where an outbreak will occur, so no provision against it can be made. A campaign on similar lines to that of Mr. Ballard would be extremely useful in Ceylon. We have to fight the same indifference but some advantage would be gained.

Mr. Ballard. As regards the parasites I have found five Tachinids and a Braconid, *Chelonus* sp. (new species).

Mr. Dutt. In 1915 we reared at Pusa *Chelonus carbonator*, Marshall, in large numbers from caterpillars of *Spodoptera mauritia*.

9.—RESULTS OF INVESTIGATION OF BIONOMICS OF *PLATYEDRA GOSSYPIELLA*, SAUNDERS, IN SOUTH INDIA, TOGETHER WITH SOME NOTES ON *EARIAS INSULANA* AND *E. FABIA*.

(Plates XIII—XV.)

By E. BALLARD, B.A., F.E.S., *Government Entomologist, Madras.*

The early history of *Platyedra gossypiella* has been dealt with at length by Ballou (1) and others and it is unnecessary to repeat it here. Suffice it to say that all evidence goes to show that it is an insect of South Asiatic origin which has spread by artificial means to almost all countries where cotton is grown, and must be reckoned as one of the major pests of the world. It has been known under a variety of names, *Depressaria gossypiella, Platyedra gossypiella, Gelechia gossypiella* and *Pectinophora gossypiella*. It is commonly called the Pink Boll-worm, but it must not be inferred from this name that all caterpillars found in a cotton boll are the larvæ of *Platyedra gossypiella*. There is a small pink caterpillar of the genus *Pyroderces** which does no harm but is a scavenger; and the larva of a Noctuid moth, *Diparopsis castanea*, Hmp., which is a true boll-worm in that it damages seed and lint. The latter insect will not however be met with in South India, as it is a native of Africa and need not therefore concern us further. Until recent years *P. gossypiella* was not looked on as a very serious pest of cotton in South India and received little or no attention. No statistics exist with which one can compare its present depredations.

The primary cotton pest was supposed to be the "Spotted boll-worm," the two species of *Earias, E. fabia* and *E. insulana*. It was also stated that exotic cottons suffered more from *P. gossypiella* than country cottons, the latter being supposed to be almost free from attack and it will be shown that in some instances this belief is not altogether in accordance with the facts.

Attention was first drawn to *P. gossypiella* in Madras Presidency by the serious deterioration of the Cambodia cotton crop in 1917-18 and in 1919 it was proclaimed as a pest under the Agricultural Pests and Diseases Act, which was put into force in Coimbatore District where a large area was under Cambodia cotton. Ordinarily Cambodia cotton

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* *Pyroderces coriacella*, Snell.

is or should be grown as a garden crop and as an annual, and before the war this was the most general practice. One to three pickings were obtained during the cotton season varying with the agricultural practices of different districts. *Raiyats* in some parts were content with a single picking (March to the beginning of May) and then pulled the crop up and prepared the land for a cereal (*ragi*). In other parts the crop would remain in the ground until September and three pickings would be obtained.

The high prices which ruled during the late war caused a great increase in the area under cotton, especially Cambodia, and in order to get the utmost from the crop most *raiyats* kept their plants in the ground for two or even three years. It was also grown as a dry crop instead of under irrigation. Thus provided with a continuous food supply, the increase of *P. gossypiella* was very rapid, leading finally to the state of affairs when it was proclaimed under the Pest Act.

The writer returned to India, after over 3½ years' absence, in May 1919 just after the conclusion of the season-picking for 1918-19 crop, and the words "Pink Boll-worm" seemed to be in everybody's mouth. In June 1919 investigations were begun of which this paper embodies the preliminary results.

The Pink Boll-worm.—The parent of the Pink Boll-worm is a small moth described by Durrant (2) as follows:—

"Dark fuscous brown, the head and thorax somewhat lighter in colour. Anterior wings with an undefined round blackish spot on the disc a little above the centre, and a fascia of the same colour crossing the wings a little above the apex, which itself is black. Under wings of a silvery grey, darker towards the hinder margin. Legs and tarsi black-brown, with the joints light. Length 4-10ths inch."

It is a member of the super-family Tineina, Order Lepidoptera. Busck (3) erected the genus *Pectinophora* in his paper in the *Journal of Agricultural Research*, Vol. IX, No. 10. It is also known as *Platyedra gossypiella*. The female moth lays from 200—400 eggs, a fact which accounts for the extraordinarily rapid increase towards the end of the cotton season, figures for which are given in another part of this paper,

Egg.—The eggs are 0·52 to 0·54 mm. in length, rather flattened, striated and iridescent under the microscope. They are laid on the bolls or thrust between the bracts and the side of the boll. Young half-developed bolls are preferred as a place for oviposition to buds or flowers; but eggs are also laid on these latter early in the season before the bolls form.

Larva.—The egg period varies from three to seven days. The just hatched larva measures 2 mm., with a dark head and prothoracic shield.

It is colourless and very difficult to see against the lint or the wall of the cotton boll.

Immediately after hatching it bores its way into the boll, usually from the side, frequently from the top, or very rarely from below. Once inside, the wound caused by its entrance closes up and nothing can be seen to show that there is a boll-worm inside the boll. This disposes at once of the suggested remedy so often advocated, to pick all first-attacked bolls. When the larva has effected its entrance into the boll it generally begins to bore its way into a seed at once, and remains in it until the contents are finished ; it then moves on to another seed. It does not necessarily remain in one lock but often cuts a hole through the septum and invades the neighbouring lock. (Plate XIII, figures 1—4.)

The number of seeds destroyed by a pink boll-worm seems to vary, some seeming to require more food in a boll of the same age than others. Very young bolls when attacked are generally entirely destroyed. When flowers are attacked the larva feeds on the anthers and may descend later to the ovary. Open flowers appear to be preferred to flower buds.

The characteristic pink colour is acquired as a general rule in the last two instars before pupation but larvæ which have fed in open flowers remain cream-coloured. The length of the larval life varies and this question will be dealt with later.

Pupa.—The pupa is a small object, 5·75 mm. to about 8 mm. in length, and enclosed in a cocoon spun by the larva. The pupal period varies from seven to fifteen days.

Pupation takes place either in the boll, amongst the lint, inside the seed, in double seeds, *i.e.*, two seeds spun together, in the bracts or at the base of the boll, or in cracks in the soil. Several cases have been seen of pupæ formed in the septum between two locks inside the boll. The larvæ appear to prefer a corner of some kind against which to spin the cocoon. For example, a batch of mature larvæ was confined between watch glasses and spun their cocoons all round the edge where the two glasses joined.

Although a point of some importance, it is doubtful how long the moth lives after emergence as it is a thing very difficult to test in nature. Under laboratory conditions moths lived for as long as 14 days, but this is no proof that they live so long or so short a time in a natural environment.

Busck ([3]) states that they have been kept alive with care for 34 days.

Most of the foregoing facts have been ascertained by a number of different workers and on the whole *P. gossypiella* in South India behaves similarly to *P. gossypiella* in Egypt, Northern India or Hawaii.

EXPLANATION OF PLATE XIII.

Bionomics of *Platyedra gossypiella*.

Fig. 1. Bolls opened to show damage done by *P. gossypiella*.
Fig. 3. *Kapas* (lint) stained by *P. gossypiella*.
Fig. 4. Parasitic larvæ in a cotton-boll.
Fig. 5. Larva of *Microbracon* sp. much magnified.
Fig. 6. Beetle larva found in cotton-bolls.

PLATE XIII.

BIONOMICS OF PLATYEDRA GOSSYPIELLA.

Short and Long Cycle Larvæ.—Apart from the actual damage it does to the seeds of the lint, *P. gossypiella* possesses another habit which helps to make it a danger to cotton growers and has been largely responsible for its world-wide distribution. This habit is that at certain seasons of the year it produces two kinds of larvæ, known generally as short-cycle larvæ and long-cycle larvæ. These larvæ either complete their lifehistory in three weeks or a month from the time of hatching or remain in the larval state for any time up to two years. Lefroy ([4]) states that in Northern India there are two such periods in the year, when long-cycle larvæ are produced, but generally it is only at one time. In Egypt this is towards the end of the year. This resting stage is passed in the seed, generally inside double seeds, that is to say, two seeds bound together by the larva with silk. It is unnecessary to emphasize how dangerous is this capacity for prolonging the larval life and how easily this may be the cause of infection of the growing crop. It helps the insects to defy the laws which decree a dead period between the pulling up of one crop and the sowing of another in the hope of starving the pest out of existence. For this reason, in Egypt all seed has to be treated as soon as it is ginned and precautions have to be taken to screen seed and *kappas* stores, as they would otherwise be easily the cause of infection of the growing crop([1]).

Our investigations for 1919-20 go to show that it is extremely doubtful whether this resting or long cycle type of larva is produced in South India. What the factors are which induce this resting stage or prohibit it are unknown. It may be that the absence of any cold weather in South India inhibits any tendency for *P. gossypiella* to produce long-cycle larvæ but, whatever the cause, as far as we can tell at present they are never or only very rarely produced. Double seeds have been found but either without a larva inside or containing a pupa. Large quantities of infested seed, *kappas* and bolls have been kept at the Insectary and examination has been made of seed stores but in practically every case no moths emerged more than a month after ginning or picking. Three cases are recorded, two from a seed store in which two moths emerged early in November from seed ginned in May or June. One larva was found in a cocoon made in *kappas* picked three or four months previously. The exact date of ginning and picking was not available in each case.

Damage.—The damage done by the pink boll-worm is difficult to estimate in terms of money. So many different factors are involved and what might apply to one field might not apply to another. The damage is done in four or five ways.

(1) By the seed being destroyed.
(2) By the development of the lint being retarded and lint weakened.

(3) By causing premature opening of the boll and invasion of saprophytic fungi, *Nigrosporum* and others.

(4) By staining the lint both in the gin and in the boll.

(5) As pointed out by Gough (5), by lowering the germination power of un-attacked seeds in an attacked boll (see table V).

The number of seeds destroyed in each boll varies very much. Sometimes all five locks or all three locks will be destroyed, sometimes only one, and the remainder produce what appear to be good lint and seeds.

The number of attacked bolls at any given date does not give one any accurate idea of the cash value of the damage done nor of the extent of the infestation.

At the time of the first picking this year (March 1920) examination showed that out of 100 bolls containing approximately 2,900 seeds (a Cambodia boll averages 28-30 seeds per boll) only 14 seeds were destroyed, that is, in all exactly half a boll. The number of bolls damaged or in which *P. gossypiella* was found were three. Therefore in this case the percentage of bolls damaged equals 3 per cent. and damage to seed approximately 5 per cent. This example is given just to show that the number of bolls attacked can only give a general idea of the actual amount of damage. On the other hand a percentage of bolls attacked combined with a percentage of boll-worm population gives a fairly accurate idea of the degree of infestation.

It must also be remembered that towards the end of the season the boll-worm population increases to a tremendous extent and that as many as eight boll-worms of the same or different ages will be found in one boll, whereas at the beginning of the season this multiple infestation is rare. Therefore 40 per cent. of bolls attacked at the beginning of the season is not so serious a loss as 40 per cent. attacked later on.

Infestation of the 1918-19 crop. The first lot of bolls examined was from a lot of Cambodia cotton grown in the wet lands belonging to the Central Farm at Coimbatore. This was an experimental plot of about an acre in extent, the nearest cotton being about 800—1,000 yards away. This gave the following results :—

Date.	Number of bolls examined.	Percentage of bolls damaged.	
		Platyedra.	*Earias.*
30th June 1919	500	41·4	2·2

In July of the same year 1,000 bolls of Uppam cotton were examined. Uppam is grown as a dry crop and is a" country cotton."

DATE.	Number of bolls examined.	PERCENTAGE OF BOLLS ATTACKED.	
		Platyedra.	*Earias.*
15th July 1919	500	60·625	0·6
31st July 1919	500	62·2	*Nil.*

Cambodia cotton from the Central Farm gave the following results :—

DATE.	Number of bolls examined.	PERCENTAGE OF BOLLS ATTACKED.	
		Platyedra.	*Earias.*
31st July 1919	500 (field 44).	84·6	0·6
31st July 1919	500 (field 15·C.)	75·4	0·6

After this date all cotton was pulled out except for a small plot in the Insectary compound. 982 bolls from this were examined in September and gave 91·65 per cent. attacked by *Platyedra* and 8·35 per cent. by *Earias*. In October 2,500 bolls were examined and showed the percentage damaged by both *Platyedra* and *Earias* was 77·08 of which *Platyedra* was responsible for 90·35 per cent. and *Earias* for 9·65. Examination of 345 bolls in the first week of November showed that of 284 damaged, 40·8 per cent. was due to *Platyedra* and 30·1 per cent. to *Earias*. After this date the last cotton plants were pulled up. The plots from which the bolls were taken after the first of August was so small that no very great importance is attached to figures after that date. The great point of interest is the rise in percentage attacked by *E. insulana* or *fabia*. The 1919-20 crop was sown in September-October as usual. 1,410 attacked flower buds from this crop were examined between 1st and 14th December. Of these 1·9 per cent. were attacked by *Platyedra* and the remainder by *Earias*. In the week ending 22nd December

1919 the first counts of population of *Platyedra* were begun and these were continued weekly until the following July. At first 2,000 bolls were examined weekly, this then had to be reduced to 1,000 and finally to 200.

This was unsatisfactory as, working with small numbers, the error is liable to be greater than working with large numbers, but, for causes which it would be unprofitable to discuss here, from the middle of March to the end of July the supply of bolls had to be limited.

The result of this examination is shown in the accompanying "graph" (Plate XIV, fig. 1.)

At the beginning of the season the crop was very backward and the number of buds and flowers was small; there was a good deal of boll fall also due, as far as could be ascertained, to a small (Capsid). Towards the end of January there was a great increase of buds and flowers and the percentage population consequently fell rapidly. It rose and fell again just after the season-picking and went up with astonishing rapidity in the month of July, more especially in the last fortnight.

Arrangements had been made for a weekly supply of bolls from various typical tracts of the District, but except in one case this supply was not forthcoming after March. So the results obtained from the Insectary cotton plots could only be checked with one other place in the District, some 35 miles south of Coimbatore. This curve (the Pollachi curve) follows the same course as that at Coimbatore, but, as all cotton in Pollachi was pulled up early, examinations of bolls up to 3rd July 1920 only were possible. (Plate XIV, fig. 2.)

Periodically bolls were sent in for examination from districts which had not been brought under the rules of the Pest Act. The amount of boll-worm attack in these districts varied very much, the highest being 75 per cent. and the lowest 45 per cent. for the "Kar" or second picking. (See tables).

From the end of March up to the end of the season measurements were taken of all pink boll-worms found in green bolls, and they were then grouped under three heads, those less than 5 mm., those over 5 mm. but under 10 and those of ten and over. The percentage of these to one another found at any time or over any period should give some idea of the appearance of fresh broods and the length of the average life in the larval state. (Plate XV, fig. 1.)

The curves would seem to indicate that during the hot months of the year the larval life is longer than later on. To put it in another way, during the time of the season-picking a very high proportion of boll-worms found are under 10 mm., that is to say, they are not in the last

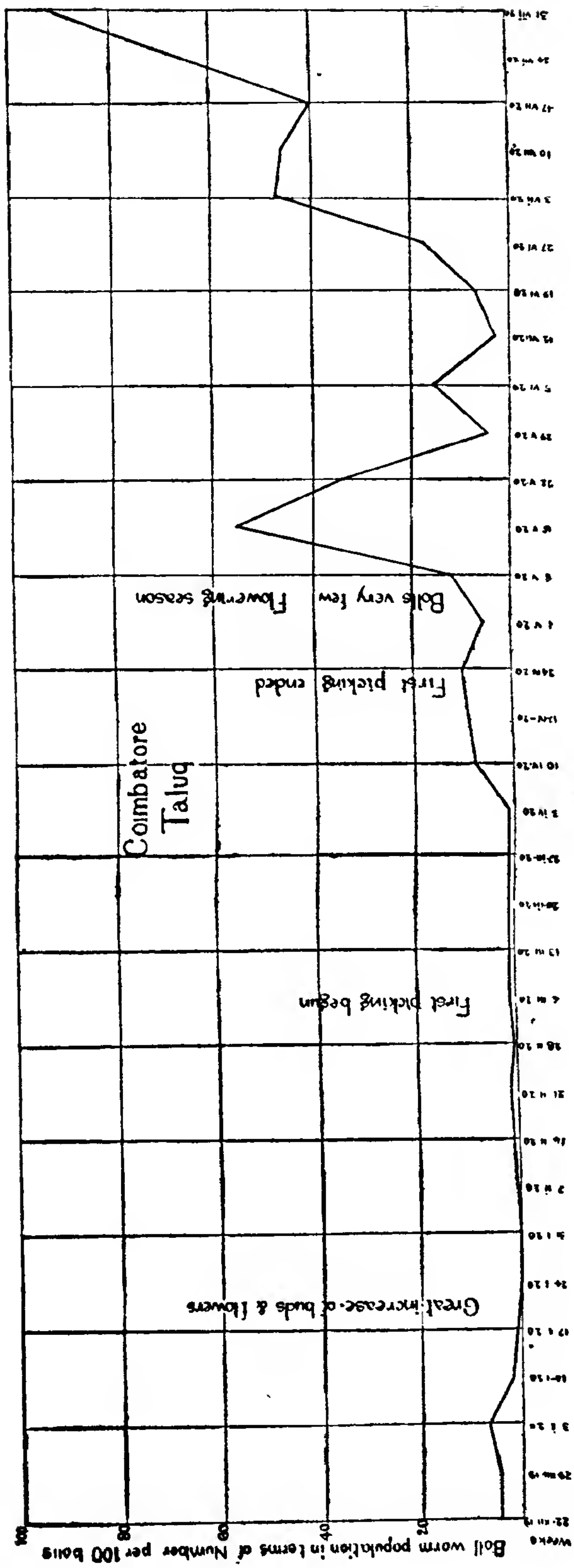

Coimbatore Taluq
Bolls very few Flowering season
First picking ended
First picking begun
Great increase of buds & flowers
Boll worm population in terms of Number per 100 bolls
Weeks
100
80
60
40
20

Fig.—1.

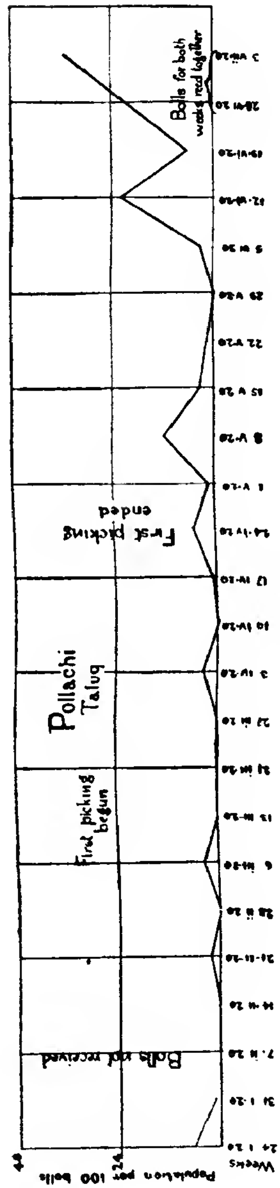
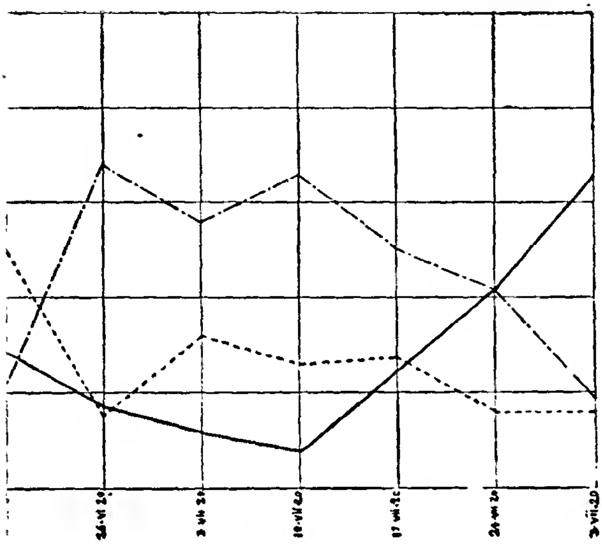
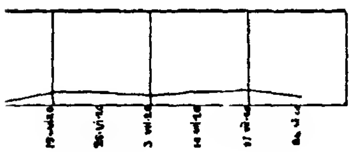

Pollachi Taluq
Bolls for both weeks read together
First picking ended
First picking begun
Bolls not received
Population per 100 bolls
Weeks
48
24

Fig.—2.

PLATE XV





instar prior to pupation, and the idea that the larval life is longer at this time of the year is borne out by the fact that the percentage of population on the whole shows little or no increase until towards the end of the season-picking, whereas after that period the rise is steadily maintained, allowance being made for experimental error. For example, the sudden drop shown in the curve in the week ending 12th June 1920 was probably due to an insufficient number of bolls being examined. However, this may not be the whole reason, for Pollachi boll examinations show a similar fall about the same period.

The season-picking ends in the last week in April, the fresh flush of bolls after this, the bolls, that is, which will produce the " Kar " picking, ripen rather more quickly and it is possible that the high winds prevailing from June onwards help to dry the bolls and consequently to shorten the larval period of the boll-worms so that generations succeed one another more rapidly.

In this connection it may be said that the very few cases of prolonged larval life or anything approaching long-cycle larvæ occurred in the season-picking and not in the " Kar " picking. As already stated, however, in South India the increase in number of bolls attacked during the season is not complicated by moths produced from long-cycle larvæ of the year before. Nearly all bolls examined towards the middle of July from all districts showed a proportion of full-grown boll-worms, indicating that in the last week of July or the first week of August a big crop of moths and consequent number of boll-worms was to be expected. This would account for the very great measure of success attained in the application of the Pest Act. The amount of damaged crop was very small and Cambodia cotton from Coimbatore realised Rs. 200 per Kandy above Broach, which in other years equalled or excelled Cambodia.

Tables are given showing the relative increase of *Earias* (*Earias* here includes both *E. fabia* and *E. insulana*) during the season. In October and November 1919 *Earias* did a great deal of damage in the Central Farm to the top-shoots of the young cotton plants. It was equally prevalent out in the District but did not appear to have caused so much damage. Some *raiyats* even said it was a blessing in disguise as it topped the plants and made them branch and produce more bolls, an opinion which the condition of their crop justified. (Plate XV, fig. 2.)

It will be seen that towards the end of the year *Earias* increases in numbers rapidly and maintains that ascendency until the first flowering season is over, after which time the percentage falls again. Towards the end of the " Kar " season large numbers of *Earias* larvæ were found,

not in the cotton crop but in two species of *Abutilon* which are common weeds in the cotton fields.

Examination of large numbers of bolls from several Cambodia cotton tracts and also from districts where " country " cottons were grown, bore out the observation that *Earias* is not as a rule a serious pest during the greater part of the season.

The Pest Act.—The results of the Pest Act being enforced in Coimbatore district were most encouraging in spite of evasion of the Act in some cases, and ignorance, apathy, and passive resistance on the part of some of the subordinate revenue officials and village officers. It remains to be seen whether the extension of the area under the Act will be attended by equal success.

The control of the pink boll-worm in South India seems to lie in the direction of strict enforcement of the Act, in the encouragement of grazing off bolls by sheep and goats before the plants are pulled up, and in the selection of an early-maturing strain of cotton. This applies more especially to Cambodia cotton. The fact that the pink boll-worm shows no signs of producing long-cycle larvæ makes control by the above means more easy and obviates the introduction of machines or other apparatus for fumigating or otherwise treating the seed after ginning.

Indeed, it is very doubtful whether it would ever be possible to enforce treatment of seed by hot-air machines in South India, and it would be useless to recommend a measure which could not be made obligatory for ginning factories.

Natural Enemies.—The larva of *P. gossypiella* is parasitized by *Microbracon lefroyi* and *Apanteles* sp. but the amount of check exerted by them is not great.

In one instance the nymph of what appeared to be a Reduviid bug was seen sucking eggs laid in captivity on a young boll, but it could not be reared to maturity. The eggs, needless to say, failed to hatch. This was the only occasion that the eggs were found to be so attacked.

The matter comprising this paper is in many respects very incomplete but gives an idea of the boll-worm situation in Southern Districts of South India at the present time.

In conclusion I wish to render my thanks to Mr. H. C. Sampson, Deputy Director of Agriculture, V and VII Circles, and to the District Staff, for help rendered, and to the Acting Government Economic Botanist, Rangaswami Ayyangar, who performed the germination tests shown in Table V.

TABLE I.

Percentage of green bolls and buds attacked by Platyedra gossypiella and Earias fabia and E. insulana, on Central Farm, Coimbatore.

Week ending.	*Platyedra.*	*Earias.*
29th December 1919*a*	4·5	9·75
3rd January 1920*a*	6·85	3·55
10th January 1920*a d*	2·8	No record.
17th January 1920*a d*	1·1	2·5
24th January 1920*a d*	·5	·65
31st January 1920*a d.*	·3	·45
7th February 1920*a d*	·25	·4
14th February 1920*b*	·6	·6
21st February 1920*b*	1·0	2·1
28th February 1920*b*	1·2	1·1
6th March 1920*b*	·8	2·6
13th March 1920*b*	1·1	1·0
20th March 1920*b*	16·0	16·0
27th March 1920*c*	1·0	3·5
3rd April 1920	1·0	·5
10th April 1920	7·5	3·5
17th April 1920	9·0	10·0
24th April 1920	10·0	7·5
1st May 1920	2·5	3·5
7th May 1920	10·0	3·0
15th May 1920	33·0	2·0
22nd May 1920	21·0	2·0
29th May 1920	4·5	5·0
5th June 1920	10·5	2·5
12th June 1920	3·0	1·0
19th June 1920	6·0	3·5
26th June 1920	14·0	3·0
3rd July 1920	42·5	2·5
10th July 1920	45·0	3·5
17th July 1920	41·5	4·0
24th July 1920	34·1	3·1
31st July 1920	51·0	2·5

	Bolls.
a Examined weekly	2,000
b ,, ,,	1,000
c ,, ,, after this date	200

d Also damaged by *Heliothis obsoleta.*

Platyedra.—Percentage of buds or bolls attacked by *P. gossypiella.*

Earias.—Percentage of buds or bolls attacked by *Earias insulana* and *Earias fabia.*

Table II.

Examination of bolls from Central Farm to check results at Insectary.

Cambodia cotton. Percentage of green bolls attacked on the Farm lands

	Per cent.
10th July 1920.—200 bolls examined—	
Platyedra population	106
Earias ,,	12
Percentage of bolls attacked by *Platyedra*	42
,, ,, ,, ,, *Earias*	6
Maximum number of *Platyedra* found in one boll	3
17th July 1920.—200 bolls examined—	
Platyedra population	151
Earias ,,	4
Percentage attacked by *Platyedra*	42·5
,, ,, ,, *Earias*	2·0
Maximum number of *Platyedra* found in one boll	6
24th July 1920.—200 examined—	
Platyedra population	168
Earias ,,	10
Percentage of bolls damaged by *Platyedra*	55·5
,, ,, ,, ,, *Earias*	5·1
Maximum number of *Platyedra* found in one boll	5

Table III.

Comparison of attack on country cottons on Central Farm, 1919 and 1920.

*Uppam * cotton.*

17th July 1920.—250 bolls examined—	
Platyedra population	54
Earias ,,	*Nil*
Percentage damaged by *Platyedra*	21·6
24th July 1920.—250 bolls examined—	
Platyedra population	70
Earias ,,	*Nil*
Percentage damaged by *Platyedra*	23·2
15th July 1919.—500 bolls examined—	
Percentage damaged by *Platyedra*	60·625
,, ,, ,, *Earias*	·6
31st July 1919.—500 bolls examined—	
Percentage damaged by *Platyedra*	62·2
,, ,, ,, *Earias*	*Nil*

* *Gossypium verbaceum.*

*Karunganni * from Central Farm.*

17th July 1920.—250 bolls—

Platyedra population	36
Earias ,,	10
Percentage damaged by *Platyedra*	17·6
,, ,, ,, *Earias*	4

24th July 1920.—250 examined—

Platyedra population	38
Earias ,,	5
Percentage damaged by *Platyedra*	15·2
,, ,, ,, *Earias*	2·0

TABLE IV.

Bolls from other districts for comparison with Table I.

Virudupatty, Trichinopoly District, Usilampatti tract.

17th July 1920.—1,000 bolls examined—

Platyedra population	463
Earias ,,	2
Percentage damaged by *Platyedra*	42·9
,, ,, ,, *Earias*	·2

3rd July 1920.—730 bolls Dindigul tract—

Platyedra population	591
Earias ,,	5
Percentage damaged by *Platyedra*	80·9
,, ,, ,, *Earias*	·06

5th June 1920.—Salem District. 212 bolls—

Platyedra population	7
Earias ,,	13

Details incomplete.

14th August 1920.—Salem. 100 bolls from Namakal Taluq—

Percentage attacked by *Platyedra*	63
,, ,, ,, *Earias*	*Nil.*

TABLE V.

	Per cent. germinated.
Germination of seed sample from unattacked bolls-Coimbatore	59·1
Germination from mixed sound seed taken from attacked and unattacked bolls	42·0
Sound seeds from attacked bolls—	
Sample (*a*)	31
Sample (*b*)	32

List of other food-plants of Platyedra gossypiella in South India :—

Abutilon indicum.

Hibiscus esculentus.

* *Gossypium obtusifolium.*

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Who named your *Microbracon* as *lefroyi*? When I was at Coimbatore two years ago in April with Mr. Sampson, just before Mr. Ballard returned, I saw attacked cotton and brought seeds up here. At that time there were a certain number of double seeds to be found, and I got a Braconid parasite as noted in the paper on Cotton Boll-worms. We also get *P. gossypiella* parasitized by *Microbracon* up here, but I should not like to say that it is *M. lefroyi*.

I think it was named in the collection. It corresponds with the picture of *lefroyi*. It does not seem to exert much influence.

What is the method of cultivation of cotton followed at Coimbatore ?

It is sown in September or October according to the time of the arrival of the North-east monsoon. It is irrigated three times. The plants have to be pulled out by the 1st of August. The first picking is at the end of March and continues through April ; the second in July. This enforced pulling by the end of July leaves just time for the second picking. Before the Act was passed the plants used to be left in the ground for three to seven years. Even the second picking in 1919 was useless, as the lint I saw in the ginning factories was stained and bad.

Does the Act apply to all kinds of cotton grown in the scheduled area ?

No ; it applies only to Cambodia but it has recently been extended to include American Dharwar, grown like Cambodia.

Do you know the percentage of parasitization ? Is there disease on the worms ?

No. I have once or twice seen a disease like Pebrine.

10.—*OXYCARENUS LAETUS*; THE DUSKY COTTON BUG.

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

Oxycarenus lætus, Kby. W. L. Distant. *Fauna of India*, Vol. II, p. 43, Fig. 31.

Oxycarenus lætus, Kby. H. Maxwell Lefroy. Insects of Tirhut. Records of Indian Museum, Vol. III, part 4, No. 25, December 1909.

Oxycarenus lætus. H. Maxwell-Lefroy. Indian Insect Life, p. 688, Fig. 454, 1909.

Oxycarenus lætus. T. Bainbrigge Fletcher. Some South Indian Insects, pp. 482-483, Fig. 367.

Oxycarenus lætus. H. Maxwell-Lefroy. Indian Insect Pests. pp. 107-108, Fig. 126.

Hitherto the Boll-worms *Earias fabia*, *E. insulana*, as well as the Pink Boll-worm, *Platyedra gossypiella*, seem to have received the greatest attention of the workers on cotton pests. The large and small Hemiptera, which cause as much damage to the cotton plant as the three boll-worms together, have received scant attention up to this time. Any one who has worked on the cotton pests will be struck with the damage directly or indirectly brought about by these obscure Hemiptera about which Order of insects Dr. D. Sharp has aptly said :—

" There is probably no order of insects that is so directly connected with the welfare of the human race as the Hemiptera ; indeed, if anything were to exterminate the enemies of Hemiptera, we ourselves should probably be starved in the course of a few months." (Cambridge Natural History Series, Vol. VI, p. 533.) And the late Mr. Kirkaldy has expressed himself in much the same view in Bull. Hawaiian Planters' Association, Vol. I, p. 271, when he said :—

" It is not alone the exhaustion consequent upon the rapid draining of plants' juices by the almost microscopic setæ of the Hemipteron that is so deleterious, it is the addition of hordes of fungus spores, which so often subsequently attack the wounded surface, and quickly multiplying penetrate into the tissues of the plant, causing decay and death," and any one who has worked on the group for some time will be struck with the validity of the above remarks.

I have been intimately connected with investigations regarding cotton pests for the last sixteen years and I quite agree with Dr. L. H. Gough when he says :—

" *Oxycarenus* is a very bad pest with us, and there is going to be special investigation regarding it. If it attacks garden hollyhock of the European variety, the leaves curl up and budshedding occurs. Forty per cent. of the flowers fail to mature on account of the sucking of *Oxycarenus*. I believe that about 80 per cent. of the seeds of cotton are rendered useless by the insect .... " (Proc. Third Entl. Meeting, Vol. II, p. 561).

And from what has been observed by me during the past, it appears that the little obscure bug is equally bad on cotton in this country as well. Its small size and obscure colour renders it an inconspicuous object on the leaves, the bolls and the flowers. The ordinary cultivator does not mark its presence, and it is for this reason that very few complaints are received regarding the damage brought about by it. In the case of leaf-eating Lepidoptera and Coleoptera the presence of damage to leaves is a sufficient evidence of the presence of the pest, though the aggregate loss caused by these may be nothing in proportion to the damage done by the sucking insects, which not only directly injure the seed and thus lower its future vitality but indirectly introduce a host of fungoid and bacterial diseases which conjointly reduce its vitality to a minimum and this aspect of the injury is of great importance when we consider the question of the seed supply of the country. At present the area under cotton is :—

Province.	Area in acres.	Yield (bales).
1. Bombay	4,526,000	740,000
2. Central Provinces and Berar	4,475,000	511,000
3. Madras	1,773,000	300,000
4. Punjab	2,089,000	592,000
5. United Provinces	1,158,000	335,000
6. Sind	290,000	67,000
7. Burma	334,000	68,000
8. Bengal	70,000	21,000
9. Bihar and Orissa	75,000	15,000
10. North-West Frontier Province	37,000	6,000
11. Assam	34,000	12,000
12. Ajmer-Merwara	42,000	24,000
13. Hyderabad	2,138,000	498,000
14. Central India	1,268,000	196,000
15. Baroda	791,000	127,000
16. Rajputana	366,000	76,000
17. Mysore	108,000	33,000
TOTAL	19,704,000	3,621,000

If we take the seed rate to be 12 lbs. per acre the total quantity of seed actually required for sowing purposes to cover the area quoted above, would be 236,448,000 lbs. If 20 per cent. of this seed is bad, the actual loss on seed account is Rs. 6,76,400 at the rate of 16 lbs. for a rupee. This is a very conservative estimate but instances have come to my knowledge where the direct loss caused by the bugs was considerably more than 20 per cent. Besides this, there is another and far serious loss and it is that is the cause of lowering the vitality of the plant which in such a condition becomes more amenable to the attack of insect pests and fungoid diseases. When once such a state of affairs has been started, the lowering of the vitality of the plant continues from generation to generation. No steps have been taken in the past or are likely to be taken in the future to arrest the degeneration and deterioration of the seed supply which is of so vital importance to cotton growing in this country, as well as elsewhere. This state of affairs is brought about by two bugs. The one, called the Red Cotton Bug (*Dysdercus cingulatus*), and the other the Dusky Cotton Bug (*Oxycarenus lætus*). Both injure the lint as well as the seed. The former feeds on the bolls and can suck out the mucilaginous matter within the seeds with its long, strong rostrum. It is conspicuous on account of its bright scarlet colour, but the other, *Oxycarenus lætus*, is small and of obscure colour which makes it an inconspicuous object on the bolls or the leaves, and it is for this reason that very few cultivators have an idea of the insidious loss caused by it. The bugs, both nymphs and adults, prefer to feed on open bolls. Their rostrum is not so long as well as powerful, as to reach the mucilaginous matter of the seed within the half opened boll or bolls. Thus they have been found to breed in large numbers in bolls damaged by the boll-worms, *Earias fabia* and *E. insulana*. In fact a serious attack of the boll-worms is followed by a serious attack of the Dusky Cotton Bugs. The bugs cannot feed well in unopened bolls. Thus in years when the attack of boll-worms is bad the cultivator leaves the damaged half-opened bolls on the plants and it is in these that the bug multiplies. When the attack of boll-worms is not bad, there is a smaller number of damaged bolls on the plants, and the cultivator plucks off all the opened bolls. In normal years, however small may be the damage done by the boll-worms, a fairly good percentage of the seed is more or less damaged by the dusky cotton bug. The damaged seed, if cut open and examined, will be found to be not so healthy as the unaffected seed. If such a seed is sown, the resulting plant from it is sure not to be so healthy and vigorous as one grown out of a healthy, unaffected seed. If, however, the seed of the affected trees again becomes damaged by the dusky bugs, the damage is intensified and if the seed from the second lot is sown, the plants from

these are sure to be not so healthy as they should have been. This phase of the question opens up new fields for investigation. The bug not only injures the seed but is the immediate cause of the reduction of the vitality of seed through successive generations so as to render it more amenable to the attack of the insect pests and possibly fungoid diseases. The bug affects the flowers and the buds and is the immediate cause of the shedding of these in enormous numbers. Anyone who has noted this fall, especially after a light shower of rain accompanied by wind, will have been struck with the amount of loss brought about by such a premature shedding. I do not here wish to convey the impression that the fall of the bolls is entirely due to the action of the dusky cotton bug. It may be possibly due to a special disease, not well known and investigated by this time, but which has been given the name of the boll disease in the West Indies. These investigations on this disease are in course of progress and it is expected considerable light will be thrown on the mysterious disease. If the premature fall of the bolls could, by any means, be checked or restrained, the damage done by the boll-worms will be inconsiderable. To my knowledge, this fall of the flower buds, flowers and newly set bolls is far more than the percentage of bolls damaged by the boll-worms, *Earias fabia*, *E. insulana* and *Platyedra gossypiella*. Of course, I have no doubt that this premature fall may be due to physiological causes, connected with sub-soil moisture, soil aeration, drainage, manure and the peculiar susceptibility of the particular variety or varieties of cotton to this cause.

The damaged seeds become light and somewhat discoloured. In a few localities where cotton cultivation is much advanced and the cultivators are intelligent enough to safeguard the loss of time and money, the seeds are tested prior to sowing. They are roughly rubbed with the hands previously moistened with a mixture of cowdung and well sifted earth. This has the effect of removing the lint or adhering it to the seeds. Thus given a preliminary treatment they are thrown in a tub of water. Any that float on the top are rejected, those that sink in the water are taken out, pickled again with a mixture of cowdung and earth, well rubbed with hand and aerated in shade. Thus some rough and ready selection of seeds is done but is not very satisfactory. What is required, is a better method of prevention of the loss and selection of the seed, so as to raise its vitality so as to produce plants which would throw off the attack of the insect pests or minimize it to such an extent that it will not be felt appreciably.

Hitherto only one species of the bug, *Oxycarenus lætus*, has been noticed by me, but there are records in previous Indian literature wherein *Oxycarenus lugubris* has been recorded from Serin ratam, Lahore

Nagpur, Baroda and Ceylon. I am not sure of the species of *Oxycarenus* occurring on cotton in Ceylon but the Indian species seems to be *Oxycarenus lætus*.

The adults as well as the nymphs freely move about the cotton plant, more so in the bolls. They attack the cotton seed for the sake of the mucilaginous matter within them. If, however, an affected seed is cut open and examined, it will be found discoloured within. If the lint be digested, and the coating of the shell examined under high power, it will be found to contain a number of very fine holes, probably the pricks made by the rostrum of the bug. It moves about freely in the bolls and the seeds in bolls are pricked by a number of adults passing the half-opened bolls. It has wings but they do not seem to be functional. It runs fast and seldom uses them for flight.

The eggs are laid in the lint of the half-opened bolls, between the calyx and the boll, but when the egg laying is at its maximum, eggs may also be seen laid at random on the bolls, the flowers and flower and leaf buds. The eggs are laid either singly or in small clusters varying from two or three to eighteen, the largest number of eggs as yet found in a cluster. An occasional count of the eggs in various clusters found on the lint and the parts of the boll was —

	No. of eggs in a cluster.
1.	6
2.	3
3.	5
4.	2
5.	11
6.	9
7.	2
8.	5
9.	18
10.	4
11.	2
12.	3
13.	10
14.	3
15.	3
16.	7
17.	5
18.	2
19.	9
20.	6
21.	3
22.	8
23.	10
24.	10
25.	2

The eggs when freshly laid are whitish turning to pale and bright pink prior to hatching of the nymph.

Egg six days after oviposition.—The eggs lie loose on the surface of the pods (*Abutilon indicum*). Each egg is 1·05 mm. to 1·14 mm. long, ·30 to ·33 mm. broad. It is elongate cylindrical, tapering at both ends, colour pale yellow. The chorion is smooth though with fine, longitudinal lines. At one end are two bright spots representing the eyes. There are two bright pinkish spots in the abdominal region, about two-thirds from the head-end. In some specimens when the chorion of the egg-shell is suffused with a pinkish colour these spots are not discernible.

Eggs eleven days after oviposition.—Each egg is 1·05 mm. long and ·30 to ·33 mm. broad, bright pale orange in colour, the chorion being striated with fine longitudinal lines. These are visible under high power only. Two bright red spots at one end mark the position of the eyes of the nymph within ; a little above the region of these spots are two small tubercles visible only under high power.

The nymph as it comes out of the egg is a grotesque little creature with prominent antennæ and rostrum which extends beyond the abdomen. It is when the nymph has fed for some time that the rostrum recedes and comes up to the middle of the abdomen ventrally.

A nymph six days after hatching.—Length ·54 mm. long, greatest breadth over abdomen ·30 mm., shiny, slaty brown, eyes bright pinkish. Head, thorax and legs concolorous, shiny brown. Head pointed anteriorly. Prothorax about twice as long as the following two segments, legs stramineous yellow, tarsal joints two with claws sharp and curved. Antennæ 4-jointed; first shortest, second and third sub-equal, fourth the longest ; joints 1 to 3 pale stramineous, fourth dark crimson. Abdominal segments 9 distinct, basal segments dull white, second and third transversely suffused with bright pink ; fourth and fifth pale stramineous ; sixth to ninth transversely suffused with bright pink ; anal segment small, pointed caudad, dark stramineous. Ventrally the rostrum reaches the penultimate segment. Under high power the antennæ appear thinly hairy with the antennal sensilla concentrated in the apical joint. Tip of rostrum dark fuscous. The anterior femur has two faint spines, one larger than the other.

A nymph moulting to emerge as an adult.—The exuvium remains attached to the posterior end of the abdomen. The front, the vertex, the ocelli, the prothorax, scutellum, base of rostrum, scape of antennæ, the apical joint of antennæ, femora bright red, compound eyes black. Second, third joints of antennæ, base of apical joint of antenna, tibiæ and tarsal joints and rostrum white. Tarsal claws and pulvilli black,

corium and connexivum brownish white, membrane translucent with the veins prominent.

The total period of a life cycle during the winter extends from 36 to 50 days.

Eggs laid	9th November 1920.
Eggs hatched	14th November 1920.
Adults emerged	15th December 1920=36 days.
Eggs laid	14th November 1920.
Eggs hatched	20th November 1920.
Adults emerged	3rd January 1921=50 days.

In one case under specific observation the copulation was found to take place 20 days after the emergence of the adults during the winter.

Dimorphism.—This has been found to occur both in adults and nymphs. In several instances the same nymph was found to have three joints in the left antenna and four in the other. In some adults the same was also seen to happen.

Distribution.—The bug has been reported from Cawnpore, Madras, Pusa, Bagpur, Belgaum, Manjri, Surat, Poona, Lyallpore, Sargoda, Hissar, Calcutta, Gojra, Coimbatore and Saidapet. But it is possible that it occurs in all the cotton growing tracts in India.

Foodplants.—It has been hitherto found or reported on :—

Cotton.
Hibiscus esculentus.
,, *cannabinus.*
,, *abelmoscus.*
Hollyhock.
Abutilon indicum.
Thespesia sp.

***Parasites and predators.*—Hitherto I have not seen any parasite on the eggs, nymphs or adults. On one occasion the small Anthocorid bug, *Triphleps tantilus*, was seen to attack the nymphs of *Oxycarenus lætus* on cotton at Pusa.**

I do not think *Oxycarenus* is responsible in South India for boll and bud fall, which is caused by boll-worms. A certain amount of destruction is caused by a small *Capsid*. *Dysdercus* is a rarity with us.

In our record which we have been keeping for the past several years I have not come across any instance of damage due to a Capsid bug.

***Oxycarenus* occurs in Gujarat but does not cause bud or boll-fall.**

Oxycarenus is never found on buds or green bolls. Only old and opened bolls are found to be infested with it. I would not include it as a pest.

It is a pest when squashed into the lint in the gins.

About a month ago I saw it in buds but not in large numbers.

From the very large numbers in which it is present, if it is a pest it ought to ruin the whole crop. I think that most of these insects do not cause damage by sucking or fungus injection, but by their salivary secretion.

In the West Indies a *Dysdercus* injects bacteria. I rather suspect the Capsid I mentioned of doing this.

We seem to know very little of the effect of the sucking of these bugs on the vitality of the seed by its attack. Experiments which we carried out on these lines were inconclusive.

I should have thought mature seed too hard to suck.

We could not keep *Oxycarenus* alive artificially on green or dry seeds.

I was in St. Vincent when Cotton Stainer (*Dysdercus* sp.) was a serious pest. It was found that these bugs could puncture bolls up to full size, and carried a fungus which rotted the seeds. It was controlled by eradicating the alternative food-plants, *Eriodendron* and other Malvaceæ. There was a campaign throughout the Island ; 10,000 *Eriodendron* trees and thousands of other trees were cut down. Now the bug is completely under control. Cotton is compulsorily pulled up and there is a close season of two months. In Ceylon we grow very little cotton, from 150 to 200 acres only, but steps are being taken to increase the acreage, and there is sure to be trouble with pests. *Dysdercus cingulatus* does damage, also *Nysius ceylanicus* and *Oxycarenus* on open bolls. There is no record of the percentage of damage. Pink boll-worm is well established and measures against it will have to be taken. *Earias fabia* is present.

Regarding the nature of the damage done by Capsids in feeding, I think mechanical injury is small, but in the case of *Helopeltis theivora* the saliva contains an enzyme which produces reactions in the plant juices which cause precipitation of part of their contents, which the bug sucks, leaving the other constituents. This causes a decrease in concentration of solutions at the point of attack, and, by the laws of osmotic pressure, a flow of substances to the area around the seat of injury, the area around the puncture being denuded of these substances. With regard to fungi and bacteria, after the proboscis is removed there is an exudation of sap at the point of puncture. The spores in the air get in by settling on this juice and thence to the seed sap. This is how the

Tea-seed bug infects the seed. The fungus is an ordinary *Penicillium*. Mr. Misra suggests germination tests to discover the amount of damage, but these would prove nothing. In the case of the Tea-seed bug germination results of attacked seed showed results of from 100 per cent. to 40 per cent.; the percentage of germination is purely accidental, depending on the course taken by the fungus in growth and on the position of the puncture, also of the time since this was made. If only the cotyledons are infected, the seed germinates and you get a plant, but if the fungus has attacked the growing point, you do not. Tests only show the damage done by the accidental growth of the fungus to the growing point. The dark discoloured area around a puncture is due to precipitation by the enzyme.

I found that these areas were caused by cork formation.

Cork forms eventually, but at first there is precipitation.

Could it not be a definite compound and not an enzyme which causes precipitation ? In the human saliva the chief enzyme, Ptyalin, converts starch into sugar. Is it not more likely that the action of the enzyme in the insect saliva should be associated with similar conversion ?

Whatever is injected behaves as an enzyme ; it starts a reaction and carries it on. Many enzymes are chemical compounds of which we do not know the formula. In this case, whatever it is, its action is enzymatic and goes on after the insect has departed. You cannot say a thing of unknown composition is not a chemical compound.

I thought, in practice, the line of demarcation between definite chemical compounds and enzymes was considered sharp.

11.—NOTES ON COTTON BOLL-WORMS (*EARIAS FABIA* AND *E. INSULANA*).

By T. N. JHAVERI, L.AG., *Entomological Assistant, Bombay.*

The species of boll-worms that are so common in Gujarat are the spotted ones, *Earias fabia* and *E. insulana*. Of these two, *fabia* is much more prevalent than the other. The Pink Boll-worm, which is so common in the Madras Presidency on Cambodia cotton, is not found here doing any perceptible damage to the crop. It generally appears about the last picking of cotton in summer, while this *fabia*, which is so common in Gujarat, specially in Surat and Broach districts, where the Herbaceum type of cotton is so largely grown, takes a heavy toll of the outturn by attacking the crop in all its stages. In the seedling stage of the crop young tender shoots are being bored and killed. In some years more than 50 per cent. of young cotton plants are found being bored and damaged; but this is not being noticed and seriously taken care of by the *raiyat*, as they do not think it worth while because at that time only the tops are being pruned, which the *raiyat* would have been obliged to do later on to stop tall growth of the crop and stimulate more branching on the side. Later on, as season advances, early bearings of the crop are seriously affected. Young buds, flowers and early developed small bolls are found infected and one notices a large number of boll-worm attack in shedded buds and flowers.

For the purpose of controlling them, as well as to find out their exact relation with the shedding of flower-buds either due to this or to the climatic conditions, some trials were made, the results of which are as under :—The control measures, that were tried, were (1) the use of Bhinda crop (Ladies' finger, *H. esculentus*) as a trap round about the cotton area, and (2) the removal of affected young shoots of cotton with boll-worms. As for the first it has been found that wherever the Bhinda crop thrived well, it successfully entrapped this boll-worm and prevented it from going to the cotton crop. In the year 1912, a small patch of Bhinda crop, about 3 to 4 Gundhas in the kitchen garden at Nadiad Farm, was found badly infested with this boll-worm in the month of September. About 80 per cent. of the plants and 50 per cent. of the pods were attacked. These were removed and this greatly helped in controlling the pest from going to the cotton area which was near by. Similar trials of controll-

ing them were made at Jalgaon Farm in East Khandesh continuously for three years during the season. Here the cotton area being very large, this trap crop was grown round about it on the border, which very effectively attracted and entrapped the pest from going to the cotton area and also realised a fairly good amount by the sale of surplus Bhinda pods as a vegetable in the market.

At Dohad Government Farm, where cotton is a new introduction, Bhinda was sown as a trap for boll-worm during the last season, which also effectively checked the pest and got in all 1,404 lbs. of pods, the sale of which realised a very good amount as a catch crop.

As for the second control of removing affected shoots of cotton by pruning, it has been found that in the year 1914, at Nadiad Farm, when the appearance of boll-worm was not much in the beginning of July the cost of pruning and removing such affected shoots came to about one anna per acre for an attack of about 2½ per cent. Later on, about the middle of July, the cost of removing the pest for the second time came to about 0-6-3 per acre for an attack of about 6 per cent. At the time of the third removal of the affected tops in the first week of August when the attack had gone to 10 per cent., the cost per acre came to about 0-9-2. One more thing was noticed about the caterpillars of this is that in the season of 1919, being a subsequent year after famine, the attack of this boll-worm was very severe. More than 50 per cent. of the bolls on the plant in the majority of cases were found infested with this about the end of November 1919 at Broach and in the beginning of January 1920 at Surat. But the untimely heavy cyclonic rain and chill, completely changed the aspect of the pest. Immediately after the cessation of this rain, it was found on examination of affected bolls on the plant that in almost all cases the caterpillars were found lying dead on them with an exudation of greenish-yellow fluid at the mouth of an aperture. Some fungus growths were also found on the body of these worms which led one to believe that they died due either to some Bacterial or Fungoid disease, for there were no Hymenopterous and other parasites present to bring about such a mortality in the worms.

As to the second problem of shedding of young flower-buds either due to boll-worms or climatic conditions, it has been observed that in the month of November 1920, the highest record due to boll-worms was of 27 per cent. and the lowest 11 per cent., while taking the average it came to about 17 per cent. That, which was caused due to climate and other environments, was 10 per cent. the highest, and 3 per cent. the lowest; while 5½ per cent. the average for this very month. Similarly in the month of December 1920, the highest record due to boll-worms was 13 per cent. and the lowest 3 per cent. while that was due to climatic

conditions, the highest shedding was of 45 per cent. and the lowest 18 per cent. In January 1921, that is in the last month, the shedding due to boll-worm throughout the whole month was nil, while that due to climate and other factors, the highest was 37 per cent. and the lowest 9 per cent.

It has been also observed that in the month of November, when we have got the highest record of shedding due to boll-worm attack up to 27 per cent., a large number of moths of *Earias fabia* was found hovering in the experimented area during the early part of the morning and evening and sitting quietly on plants in couples, from whence they were easily caught by hand. About 182 *fabia* moths were captured in this way during the month from a small plot of about 4 Gunthas.

13.—NOTES ON "*KATRA*" (HAIRY CATERPILLARS) AND THEIR CONTROLLING MEASURES.

By T. N. JHAVERI, L.AG., *Entomological Assistant, Bombay.*

The species which is so prevalent in N. Gujarat is *Amsacta moorei*. It seems to have taken a firm hold in certain tracts of the light *Goradu* soil and appears to move slowly from west to east, that is, towards the prevailing direction of the wind in the beginning of the monsoon.

Regarding the habits of the pest, it has been noticed that they are usually not found to breed and appear as pest in the tracts of heavy black soil. This, I think, is mainly due to the unfavourable condition of the soil produced by natural heavy cracking of the soil surface during summer, as well as by more retension of moisture during rainy days. In the tract where this pest appears as a pest, their moths begin to emerge from their hibernating pupæ in soil, in the beginning of the early favourable monsoon. By this I mean about 8 inches of good rain in the first week of June and soaking of the soil to a depth of about 4 inches or so. If the monsoon is delayed for about three weeks or a month, the emergence of moths is not very heavy in that year. At the same time early rains in May are also not favourable for the successful emergence of these moths.

The time of greatest emergence of these moths is chiefly at night till midnight during the break and partly in the evening and rarely during the day. This continues for about a week or twelve days depending upon the break in rains and they are greatly attracted to burning lamps and lights at night.

The distinction of sexes is rather easy in this case. The female is $\frac{2}{3}$ inches long, bigger and thicker in size with a distinct round fleshy ball at the orifice of the generative organ, which is absent in males. The male is about half-an-inch long, lean and small in size, with a slight projection of the last anal segment. After emerging, the couples unite and a female moth lays about 700 eggs in clusters of 200 to 300 on the seedlings of the early sown crops or their favourite weeds and hedge plants. These eggs hatch in a period of three to four days. The young tiny caterpillars remain feeding on their food plants for a period of about four days, thereafter they scatter and devour the crops and weeds which come in their way. In this way they become fullgrown in a period of about 20 to 24 days and the size of a fullgrown caterpillar measures up

to 2½ inches long. At that time the majority of fully developed worms are seen to go towards boundaries of fields and disappear in ground. Principally there is only one brood in a year. The second brood is rare and if it appears, it is small and not so harmful to the crop. The favourite foodplants of the pest are as under: Amongst cultivated crops, the following are badly infested :—

1. Sann.
2. Maize.
3. Til.
4. Castor.
5. Mung, Urid and Val.
6. Bajri and Banta.
7. Cotton, if sown early.

Amongst weeds and hedge plants, they principally attack the following :—

1. Thoria—Euphorbia nereifolia (Cactus plant on Nadiad side).
2. Arni—a hedge plant.
3. Chida grass—Cynodon dactylon.
4. Kathimbdi (a Cucurbit weed on Dohad side).

In short, the above are the principal points of their life history habits and foodplants. Having considered these, I now come to the vital subject of controlling this pest, the results of which are as under :—

At Nadiad Government Farm, where this pest had firmly established, I started a regular crusade against it for a period of six years from 1911—1916.

1. The first and foremost measure that was adopted against this pest was of putting light-traps in fields during the emergence of these moths for the purpose of entrapping them. This was continued for a period of six years under my personal supervision. The results of each year are tabulated below :—

A statement showing the catches of Katra moths by light-traps caught on Nadiad Farm in a period of six years.

Year.	Number of moths trapped.			Remarks.
	Number of males.	Number of females.	Total.	
1911 ..	...	...	22,409	No distinction was made between the sexes this year. The traps were ordinary hurricane lanterns with a 2 feet square and 4 inches high tin dish with water and kerosine film at the surface.

A statement showing the catches of Katra moths by lignt-traps caught on Nadiad Farm in a period of six years—contd.

Year.	Number of moths trapped.			Remarks.
	Number of males.	Number of females.	Total.	
1912 .	6,663	6,177	12,840	One Kitson light trap in two nights caught about 3,297 moths and the greater number was of females loaded with eggs (2,869 ♀)
1913 .	7,575	761	8,336	Ordinary hurricane light traps were used.
1914 .	7,330	1,732	9,062	Put traps for a fortnight. In two nights about 500 female moths were caught at a Kitson light trap. The egg-laying was very little hence a very slight appearance of caterpillars.
1915 .	1,301	400	1,701	This was a year of partial famine and late and deficient rainfall. The first rain was of about ½ inch on 26th June 1915.
1916 .	919	256	1,175	This year the moths emerged in two batches (1) from 17th to 25th June and (2) from 17th to 26th July due to a long interval of break in rains.

From the above statement, it will be noticed that the number of moths went on decreasing year after year ; side by side the egglaying and their hatching decreased to such an extent that there was in fact no perceptible appearance of Katra caterpillars in the year 1916. Thereafter from 1917, till the last monsoon of 1920, that is, in a period of the last four years, no more light traps were put in that area and no report of the appearance of Katra caterpillars was received from that direction.

2. The second controlling measure that was being tried for them was of catching these moths alive in the evening by engaging young boys and girls. In this way the following number of moths were caught :—

Year.	Number of moths entrapped.			Remarks.
	Number of males.	Number of females.	Total.	
1912 .	202	255	457	These were collected from an area of 50 acres in four days.
1914 .	53	17	70	These were collected from the same area in eight days.
1915 .	12	10	22	......

From the above record it will be seen that the emergence of these moths in the evening did not occur so much as it used to be at night.

3. The third measure that was adopted was of searching and collecting their egg-masses from their favourite food plants during the egg-laying period of these moths which will be seen from the following table :—

YEAR.	Number of eggmasses.	REMARKS.
1912	205	These were collected in four days from an area of 50 acres and each mass contained about 500 eggs.
1913	301	This collection of eggmasses cost 0-0-6 per acre.
1914	35	......
1915	......	......
1916	......	......

4. The fourth measure which was taken as the pest advanced in the stage was of the collection and destruction of the caterpillars by several contrivances.

(*a*) The first ordinary commonsense contrivance was of the collection of small and big caterpillars by handpicking. In this way, in the year 1911, 282½ lbs. of caterpillars were collected and destroyed which numbered nearly 855,260 worms at a cost of 0-9-6 per acre and this was the first year of the experiment and that of the heaviest and greatest emergence of moths and caterpillars.

YEAR.	Weight of caterpillars collected.	Number of worms.	REMARKS.
	lbs.		
1911 .	282½	855,260	Handpicked by hand which cost 0-8-6 per acre.
1912 .	50		Ditto. ditto.
1913 .	30		These were partly handpicked and mainly collected by sweeping a grasshopper bag over the crop and in grass on boundaries which cost 0-3-3 per acre.
1914 .	No perceptible appearance of caterpillars.		
1915 .	Ditto		
1916 .	Ditto		

In the year 1912 about 50 lbs. of caterpillars were similarly collected and destroyed.

(b) In the third year (1913) another cheap and effective contrivance of collecting these caterpillars by sweeping a grasshopper bag over low crops as well as in grass over boundaries was introduced, which collected from an area of about 8 acres, 30 lbs. of caterpillars at a cost of 0-3-3 per acre in comparison with that of handpicking which cost 0-8-6 per acre to collect that much quantity from the equal area.

(c) Another contrivance of preventing these caterpillars from getting from one field to another by means of simple trenching was tried but this did not prove successful owing to the following reasons. First the advance making of the trench in summer by hand digging proved very costly in light *Goradu* soil with subsequent fear of its being breached and filled with earth at each shower of heavy rain. It cost nearly Rs. 3 for making it round about a plot of an acre with a trench of 1 foot deep and 1 foot 6 inches broad at the surface with sides sloping. But instead of that if a trench is being made by means of an iron Gallom or Turnwrest plough in the beginning of the monsoon after about 4 to 5 inches of rain have fallen, it can be very easily made at a very low cost with a slight repair of the same. Such a trench was made in the year 1914 round about a plot of 3 acres of Bajri and Kadra crop at Nadiad. This was being made by means of a CT_2 plough with two pairs of bullocks. It measured 1,524 feet in length, 10 inches broad and 6 inches deep and required about 20 minutes to make it. By a heavier plough it could be made still deeper and broader. However the caterpillars entering such an empty trench from its one side will very easily crawl over it and go to the other side. To prevent them from doing so, if the bottom of the trench is strewn with Cactus leaves, green weeded stuff and grass in the evening, they remain in the trench partly feeding and partly concealed under it, from whence they could be easily picked up and destroyed in the morning.

(d) Spraying trials of Lead Chromate, Lead Arsenate and London Purple were made of different strengths but these did not seem to respond very well and in stronger doses of London Purple even with an admixture of quicklime, it used to scorch the leaves. The following strength of insecticide was used :—

Lead arsenate paste or powder	1 to 2 oz.
Jaggery	6 oz.
Quicklime	3 oz.
Water	4 gallons.

The above strength of the solution was prepared and a crop of Sann was sprayed with it as well as the leaves of the same crop were dipped in

that solution and given to two dozen caterpillars to eat in a breeding cage. Next morning on examining the sprayed crop, no dead caterpillars were found in the area nor did caterpillars appear to eat the leaves. While in a breeding cage out of two dozen worms, about 1 to 2 caterpillars were found dead, while the rest were alive and the leaves were found slightly nibbled in some cases. In the case of London purple, the following trial was made on a small scale in the field as well as in the insectary: Half to once ounce of London purple with 4 gallons of water and with or without admixture of lime were tried. The effect of spraying in the field was not favourable, as no dead caterpillars were found in the sprayed area nor leaves were eaten except very slightly in some cases. The spray had also some effect of scorching the tips of leaves. In the insectary duplicate series of one dozen caterpillars were taken and each lot was given Sann leaves to eat, dipped in the following strength of solution:—

London purple	$\frac{1}{2}$ oz.
Quicklime	1 oz.
Water	4 gallons.

Next morning on examining the cages, 10 and 9 worms were found dead in each cage respectively, and the leaves were also found slightly scorched at the tips.

(e) The poison baits of the following materials were found rather successful:—

	lbs.
Wheat bran	10
Jaggery	$\frac{1}{2}$
White arsenic	$\frac{1}{4}$
Water	9

Small baits (one teaspoonful of the above stuff) were put at short intervals at the foot of castor and other crops. The caterpillars were noticed to eat these baits readily in large numbers and died on the spot. In a breeding cage the above baits were given to 25 caterpillars. Next day, 19 of them died and the 3rd day the remaining ones died. But these baits could be only used in the advanced stage of the caterpillars while they are actively moving on the ground. The other point which is to be marked in this case is that as long as these baits remain moist in the field, the caterpillars ate them; but after drying, they did not seem to touch these.

The last controlling measure which was being tried for this pest was of digging and collecting from suspected places, the hibernating pupæ. In this way during the fair season of 1911 about 1,195 pupæ were dug out from the soil and collected. These were found mostly buried along the

boundaries of affected fields, as well as in waste lands and undisturbed hedges to a varying depth of 3 to 4 inches.

Were the light-traps and handpicking tried in the same place? This might account for the lessened numbers got by handpicking.

Both experiments were conducted in the same place.

14.—SUPPLEMENTARY OBSERVATIONS ON BORERS IN SUGAR-CANE, RICE, ETC.

(Plates XVI—XXV.)

By C. C. Ghosh, B.A., *Assistant Entomologist, Burma* (*lately Assistant to the Imperial Entomologist*).

[The information contained in the following paper was collected whilst Mr. Ghosh was Insectary Assistant at Pusa, between February 1919 and September 1920, when he was transferred to Burma. The work at Pusa on Borers was initiated by me and has throughout been carried on under my close supervision and is to be considered as a part of the activities of the Entomological Section as a whole. I have, however, been too busy in other directions to be able to spare time to collaborate in writing up these notes, other than editing for press, and therefore Mr. Ghosh's namc appears as sole author of this paper, which should be considered as a supplement to our former paper on this subject.—T. Bainbrigge Fletcher.]

Introductory.

Since the first paper (Borers in sugarcane, rice, etc., *Proc. Third Entl. Meeting*, February 1919) was written, a further mass of information has been collected on these very important pests. During this period there have been opportunities of getting a better idea of the external agents of damage and a more correct estimate of their activities as pests. As will appear later on, some of them are capable of doing far greater damage and that in a much shorter time than probably all the internal borers taken together. A few more internal borers also have come to light and fresh alternative food plants of several borers have been discovered. Therefore additions have been necessary to the list of borers and food plants and a change in the key for differentiating the pupæ. The order of treatment in the first paper is followed, additions being made where necessary. The key given in this paper for pupæ therefore supersedes that in the first paper. Illustrations of some of the insects included in the first paper were mislaid while the paper was going through the press and have been added in this paper. This paper, however, does not treat of the insects already dealt with in the first paper beyond giving more information in respect of some

of them, and should be considered as supplementary to the latter publication.

THE EXTERNAL AGENTS OF DAMAGE.

The external agents of damage should be grouped as follows :—

(1) Termites, commonly known as " White ants."
(2) Mole Crickets.
(3) Beetle grubs.
(4) Beetles.
(5) Red Ants (*Dorylus*).

There is hardly anything of importance to add with regard to Mole Crickets and Red Ants (*Dorylus*).

TERMITES.

With regard to termites, another year's cultivation of cane in the area in the Brickfield between the treated and untreated plots experimented upon in 1918 (see Plate 69 of First Paper) exhibited similar differences in the degree of infestation as recorded in the first paper. For the purpose of ascertaining as clearly as possible the damage by termites this plot was divided into five smaller plots. Analyses of the soils of the first of these small plots (counting from the east), which showed the least and of the fifth plot, which showed the greatest damage, exhibited slight differences in the constituents of the soils as given below. No experiments on the basis of these differences have yet been made.

—	Surface soil, sugarcane Plot No. 1 showing least damage by white ants.	Surface soil, sugarcane Plot No. 5 showing greatest damage by white ants
	Per cent.	Per cent.
Sand SiO°_2	53·33	53·94
Alumina Al_2O_3	5·79	3·09
Ferric Oxide Fl_2O_3	2·63	3·09
Manganese Oxide $MnzO_4$	0·032	0·05
Lime Ca O	18·78	19·33
Magnesia MgO	1·00	0·86
Potash K_2O	0·37	0·53
Soda Na_2O	0·42	0·17
Phosphoric acid P_2O_5	0·08	0·08
Carbon Dioxide CO_2	15·76	16·59
Sulphuric acid SO_3	0·12	0·09
Loss on ignition	1·69	1·48
	100·00	100·00
Organic Nitrogen	0·059	0·058
Available Potash K_2O	0·0058	0·0059
Available Phosphoric acid P_2O_5	0·0002	traces.

Beetle grubs.

Beetle grubs and beetles have been grouped separately for the reason that the grubs themselves may prove to be injurious in some cases, the resultant beetles not causing any appreciable damage. Recently in 1920 there was a report of serious damage to a young maize crop in Belgaum caused by the grubs of *Phyllognathus dionysius*. Some years ago, in 1906, from the same place there was a report of similar damage to young paddy plants by the same grubs. But the beetles have not been reported to behave as pests there. On the other hand, enormous damage was done in 1919 to about 500 acres of sugarcane in the Kamrup Farm in Assam by *Alissonotum impressicolle* beetles and not by the grubs. Also such damage cannot be caused by grubs.

The grubs of the following beetles have been observed to cause damage to gramineous plants, in some cases bringing about dead-hearts exactly like the internal borers :—

Anomala bengalensis. The larva gnawed sugarcane shoots at Pusa and Dacca in the field and bored into sugarcane setts in the Insectary.

Alissonotum piceum.—The larva gnawed into sugarcane shoots at Pusa in the field and bored sugarcane setts in the Insectary.

The grubs of the following have been observed to live in the soil among the roots of gramineous plants, apparently feeding on the roots, and some of them are reported to cause rather serious damage in this manner.

Autoserica insanabilis, Brenske. Larva among sugarcane, lemon, soybean and castor roots.

Apogonia proxima, Waterh. Larva among *Saccharum spontaneum* roots.

Unidentified Melolonthid (C. S. 1797). Larva among *Saccharum spontaneum* roots at Pusa.

Anomala polita, Blanch. Larva among rice and grass roots at Pusa, Muzaffarpur and Nadia, and also in leaf mould at Pusa.

Anomala varicolor, Gyll. Larva among *Saccharum spontaneum* and oat roots at Pusa.

Anomala biharensis, Arrow. Larva among sugarcane, *Saccharum spontaneum* and *Ficus* roots at Pusa.

Anomala dussumieri, Bl. Larva among sugarcane roots in the Kamrup Farm in Assam.

Adoretus versutus, Har. Larva among sugarcane and oat roots at Pusa. (Plate XVI, fig. 1.)

Adoretus caliginosus, Burm. Larva among rice, sugarcane, grass and *Saccharum spontaneum* roots at Pusa.

Alissonotum simile, Arrow. Larva among sugarcane roots at Pusa.

Pentodon bispinifrons (C. S. 768).—Larva among sugarcane roots at Pusa. (Plate XVI, fig. 2.)

Pentodon bengalense, Arr. Larva among sugarcane roots at Pusa.

Phyllognathus dionysius, Fb. Larva reported causing serious damage to young paddy and maize crops at Belgaum.

Rhyssemus germanus (C. S. 1204). Larva among *Mootha* and indigo roots at Pusa.

Rhyssemus sp. (C. S. 948). Larva among *Mootha* and cotton roots at Pusa.

Aphodius sp. (C. S. 1327 and 1350). Larva among *Mootha*, rice and cotton roots at Pusa.

Anomala sp. (C. S. 1314). Larva among *Mootha* roots at Pusa.

Tanymecus hispidus, Mshll. Larva among sugarcane roots at Pusa.

Myllocerus blandus, Fst. Larva among sugarcane and maize roots at Pusa.

Myllocerus discolor. Larva among sugarcane and maize roots at Pusa.

Myllocerus 11—pustulatus. Larva among maize and cotton roots at Pusa.

Amblyrrhinus poricollis. Larva among *Saccharum spontaneum* roots at Pusa.

A few more Curculionid grubs. Among sugarcane and Maize roots.

Nodostoma subcostatum, Jac. Larva among grass roots at Pusa.

Pachnephorus impressus. Larva among maize roots at Pusa.

Monolepta signata. Larva among sugarcane roots at Pusa.

Unidentified Chrysomelid (C. S. 1640). Larva among sugarcane roots.

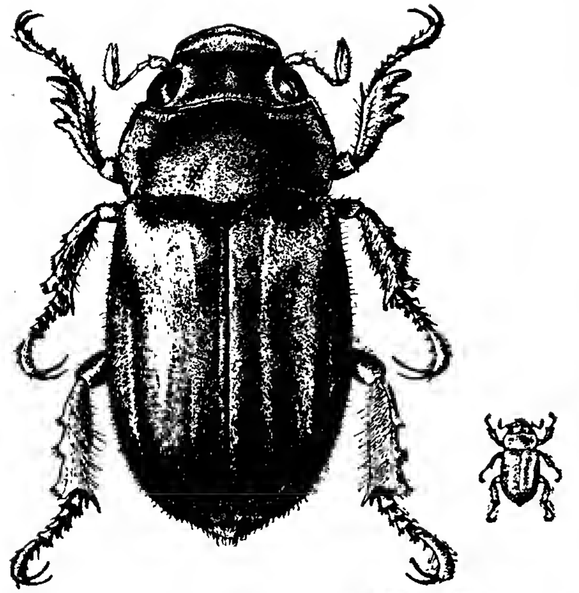
Formicomus caerulipennis. Larva among sugarcane roots.

Drasterius sp. (C. S. 1211). Larva among wheat roots at Pusa.

Carpophilus sp. (C. S. 1093). Larva among *Panicum* roots at Pusa.

Lordites sp. (C. S. 1089). Larva among *Panicum* sp. at Pusa.

To the above *Tipulid* and *Asilid* maggots found among grass and rice roots may be added.



ig. 1.—*Adoretus versutus,* Harold (magnified ; the smaller figure shows the natural size).

Fig. 2.—*Pentodon bispinifrons* (magnified ; the smaller figure shows the natural size).

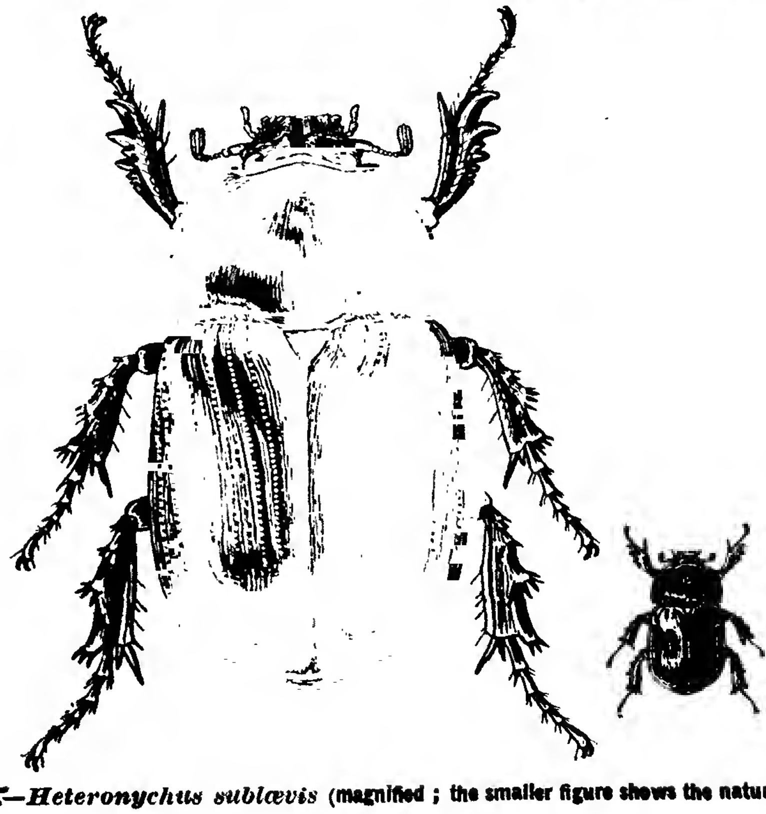


Fig. 3.—*Heteronychus sublævis* (magnified ; the smaller figure shows the natural size).

BEETLES.

The following beetles have been definitely observed to be capable of injuring gramineous plants in most cases with external symptoms similar to those caused by borers :—

Oryctes rhinocerus gnawing sugarcane setts and shoots at Coimbatore and in Travancore. (*South Indian Insects*, p. 151).

Xylotrupes gideon is known to attack sugarcane in this manner.

Alissonotum impressicolle caused serious damage to sugarcane in the Kamrup Farm in Assam in April-May in 1919 by gnawing young shoots and boring into setts and ratoon stumps. It did similar damage to thick grasses also.

Alissonotum piceum did similar damage as the above in the Kamrup Farm.

Heteronychus sublævis worked in company with the above two in the Kamrup Farm. (Plate XVI, fig. 3.)

Heteronychus sacchari recorded to have caused extensive damage to sugarcane in Rangpur. (F. I. Coleopt. *Lamellicornia*, pt. I, p. 297).

Pentodon bengalense, Arrow, gnawed into sugarcane shoots and setts in Tarnab Farm at Peshawar in May 1912.

Pentodon bispinifrons recorded to have occurred on sugarcane at Baroda, apparently causing similar damage as the above.

Phyllognathus dionysius reported to cut stems of young paddy plants in South Kanara.

Autoserica sp. observed to gnaw into sugarcane shoots in March at Pusa.

Apogonia proxima observed to live among the roots and feed on the shoots of *Saccharum spontaneum* at Pusa.

Protætia alboguttata observed at Pusa to feed similarly on *Panicum* shoots.

The beetles named above work underground and feed as shown in our former Plate. Other beetles and weevils are known to feed on gramineous plants, usually eating leaves or new shoots. Although they may cause a set back to the growth of the plants they do not kill them. The following may be mentioned :—

Tanymecus indicus is known to nibble wheat seedlings in the Punjab and *juar* (*Andropogon sorghum*) seedlings in Surat.

Tanymecus hispidus occurred in large numbers in Messrs. Turner, Morrison & Co.'s sugarcane plantations in Cooch Behar.

Tanymecus sciurus was observed by P. C. Sen to eat tender leaves of young sugarcane shoots at Rangpur.

Myllocerus blandus is commonly found feeding on tender leaves of young sugarcane, maize, wheat, rice, etc.

Myllocerus discolor and *M. 11—pustulatus* also feed like *M. blandus*.

Gonocephalum hofmannseggi, Steven., has been recorded as a pest of *Eleusine coracana* in Mysore, (Mysore Bull, No. 5, by Messrs. Coleman and Kunhi Kannan).

The Dynastine beetles may be looked upon as serious pests. Although they may not occur as regular pests they are capable of doing serious and extensive damage, as will appear from the following account of beetle pests in the sugarcane farm at Kamrup, Assam.

The Kamrup Farm is situated in the midst of an extensive piece of waste land running along the base of the Bhutan Hills and having on it a thick and mixed growth of various kinds of tall grasses. About 50,000 acres of this land is said to be capable of being rendered arable. The Farm has brought under cultivation about 800 acres divided into 18 blocks, *viz.*, 6 blocks of 60 acres, 2 blocks of 55 acres, one block of 54 acres, 2 blocks of 42 acres, one block of 34 acres, 2 blocks of 30 acres, one block of 25 acres, one block of 16 acres, one block of 15 acres and one block of 11 acres. In 1919 there were 241 acres of plant cane and 229 acres of ratoon cane. In the other plots *Sesbania* was being grown for green manuring.

The sugarcane of the entire Farm was remarkably free from borers (5th to 15th May 1919). The damage was due entirely to three species of black beetles, *viz.*, *Alissonotum impressicolle*, *A. piceum* and *Heteronychus sublævis*. They worked underground chewing and gnawing into the bases of young canes which in extreme cases were almost wholly cut across. Young buds which were somewhat grown but had not yet emerged out of the ground were also similarly destroyed. The beetles bored into setts and also into the bases of canes already formed. This form of damage to sugarcane by adult beetles on such a scale had never before been observed although sporadic cases were known as described above.

The relative abundance of the three species can be judged from the number obtained of each out of a total collection of 286 made at random in the second week of May 1919.

Alissonotum impressicolle	264
„ *piceum*	19
Heteronychus sublævis	3

They were first observed on the 10th April. They spread over the whole locality and the Farm area received its share. They did not

come to sugarcane by choice. They were equally or rather more common among the grasses surrounding the Farm and also among the grasses growing on roads running between and bordering the various blocks. Similarly they were found among grasses growing in the blocks sown with *Sesbania* (*Dhaincha*). Among sugarcane also they were practically equally prevalent in blocks which had good and apparently healthy crops, as in those which seemed to have suffered badly.

Actually however a slight difference was observed in their distribution in the different parts of the blocks. Parts where many shoots were growing had attracted more beetles. The beetles also seemed to be somewhat gregarious in habit. Among some ratoon stools as well as among some stools of the plant cane as many as 10, 15 or even 20 beetles were present. Similarly among individual grass stools on the roads of the Farm as well as outside the Farm up to 34 beetles were observed to have congregated. The number of beetles in parts of the plant cane with poor and patchy germination was much less. But a single beetle was enough to kill the solitary shoots. Where germination was extremely poor the number of beetles was still less as there was hardly anything above ground to attract them. In such parts the setts were observed to have been bored by stray beetles here and there.

It was evident that after having swarmed and spread once, the beetles did not migrate again from places where they happened to alight. It was ascertained by examination that many beetles were present underground in the South-eastern part of Block III. No hole could be observed in the surface of the soil which had been beaten down by rain. The surface was examined very carefully at night with lantern in hand. It was clear that no beetle was going out.

The beetles were mainly attracted by and fed upon new and growing shoots. Among plant canes after having fed on the shoots they went into setts if they wanted to feed longer. Similarly among ratoons they did not attack the stumps unless forced to do so for want of growing shoots.

The beetles fed for a short time after swarming and then they rested. They were not attracted to strong electric lights, nor to a bait of molasses, country liquor and ethyl acetate.

The Farm was started in 1915 and from records of rainfall kept from April 1915 it was found that from February till October the rain was fairly well distributed in 1916, 1917 and 1918. In 1919 however there was hardly any rain till 5th April.

The primary cause of the trouble was the droughty condition which prevailed up to 5th April. Parts of the Farm where the soil retained

moisture of the previous year better had a fair crop. When no moisture was retained germination was poor or extremely patchy. The sett canes in such parts lying near the surface within about two inches or less below the surface were affected by the drought and most were rotting. The beetles did not interfere with germination. They were common all over the Farm, in fact more common in parts which had a good to fair crop than in parts which had a peer crop. When the crop grew normally and tillered well the attack was hidden or rather the crop outgrew the attack.

The beetles were not new to the locality. They breed among the grass roots. In previous years normal growth of the crop consequent on the normal climatic conditions hid the attack of the beetles which did not therefore attract attention. In 1919 the local authorities estimated the damage at over 60 per cent. and ascribed the whole of this loss to the beetles. They came to this conclusion on superficial observation of the conditions. Mr. S. R. Gupta, Entomological Assistant, Assam, and the writer very carefully examined all the plots and found that the beetles were certainly responsible for about 20 per cent. of the total damage. The failure of the setts to germinate owing to adverse climatic conditions could not be ascribed to the beetles. A careful examination of the conditions led to the conclusion that in years with normal climatic conditions the beetles would not prove injurious to the sugarcane of the Farm. This was corroborated in 1920 when although Mr. Gupta found the beetles to occur in practically equally large numbers as in 1919 much damage was not caused.

Apart from their capacity to cause damage directly, the beetles and beetle grubs and in fact all the external agents of damage are responsible for probably much greater damage indirectly by affording places for the entry of fungal diseases through bites on the surface of the stems. "Chewing" described at page 361 of the first paper (Proc. Third Entl. Meeting) may be referred to in this connection.

Some beetle grubs and beetles have already proved to be very serious pests and others may certainly be looked upon as potential pests of this nature. All possible precautions should be taken against importing them into new localities. They have the chance of insidiously coming in the earth taken with plants and cuttings. To point to notable instances of this nature one has only to make mention of the entry of *Oryctes rhinoceros* into Samoa, believed to have been carried in the earth taken with rubber plants from Ceylon, and of the importation of *Phytalus smithi* into Mauritius with sugarcane cuttings from Barbados.

THE BORERS.

The following additions should be made to the list given in the first paper :—

COLEOPTERA.

Lamiadæ : Lychrosis zebrinus. (C. S. 2010).
Chrysomelidæ : Chætocnema sp. (C. S. 1891, 1923, 2043).
Scolytidæ : Xyleborus perforans, Woll.
Pyralidæ : Hypsotropa tenuincrvella, Raq. (C. S. 1920).
Chilo torrentellus, Meyr. (C. S. 2027).
Crambus corticellus, Hmpsn. (C. S. 2007).
Saluria inficita, Wlk.
Gelechiadæ : Ephysteris chersæa, Meyr. (C. S. 2046).

Potential Coleopterous borers. There is reason to believe that the Curculionid and Scolytid beetles which have of late been observed to breed in date and coconut palms in such large numbers as to bring about the death of these plants, may turn their attention to sugarcane. *Calandra stigmaticollis,* which is reported to be bad in this respect in Ratnagiri and Malabar, has been observed in the Insectary to oviposit, live and breed in sugarcane stems without any apparent inconvenience. Among Scolytid beetles, *Xyleborus perforans* already ranks as a pest of sugarcane. Therefore wherever such affected palms are present, they may be looked upon as sources of danger, not only to other palms but also to sugarcane, especially thick varities of sugarcane. A Nitidulid beetle, *Brachypeplus* sp. (C. S. 1101 and 1661) is frequently found breeding inside decaying but moist stems of sugarcane and maize. But it is not a borer.

FOODPLANTS.

I. Cultivated crops.

The following insects should be added to the lists under the different crops given in the first paper :—

Sugarcane—
Xyleborus perforans.

Rice—
Ephysteris chersæa.
Chætocnema sp.
Phycitid borer (C. S. 1837).

Marua (Eleusine coracana) :
Saluria inficita.

Kauni (*Setaria italica*) :
Sesamia inferens.

China (Panicum miliaceum) :
Chætocnema sp.

III. *Semi-cultivated plants.*

Under this heading the following plant is added as it is grown in gardens and is of economic importance :—

Lemon grass : *Sesamia inferens.*

Also the following insects are added to the lists given in the first paper :—

Ikri (*Saccharum fuscum*) :
Curculionid borer (C. S. 1778).
Batri (*Saccharum spontaneum batri*) :
Chilo torrentellus.
Lychrosis zebrinus.

IV. *Wild grasses and plants.*

The following additions are made :—

Katra (*Andropogon squarrosus*) :
Hypsotropa tenuinervella.
Procometis trochala. (Plate XVII.)
The Noctuid borer (C. S. 1666).
Rosha grass (*Cymbopogon schœnanthus*) :
Hypsotropa tenuinervella.
Scirpus corymbosus :
Crambus corticellus.
Coix lachryma-jobi var. *aquatica* :
Chilo simplex.

Differentiation of borers.

The following addition should be made to the key for larvæ :—

3. Caterpillar with grey transverse bands on segments . *Ephysteris chersæa.*
4. G. (*Saluria inficita* is to be placed in this group) . ...
   J. Colour creamy yellow. Shape hardly tapering. The segments with rather an elongated appearance and their surfaces rather chitinized and shiny . . . . *Chilo torrentellus.*
   K. Colour ordinarily red but pale yellow in pupating and hibernating caterpillars . . . . *Hypsotropa tenuinervella.*

Crambus corticellus will come under 11 but cannot be definitely placed until further material is available.

A revised key for differentiating the pupæ is given below and supersedes that in the first paper. The pupæ of the caterpillars grouped according to colour above are not likely to be confused with those of *Chilo, Diatræa* and *Argyria.* For the same reason *Raphimetopus* (*Anerastia*) *ablutella* is also omitted.

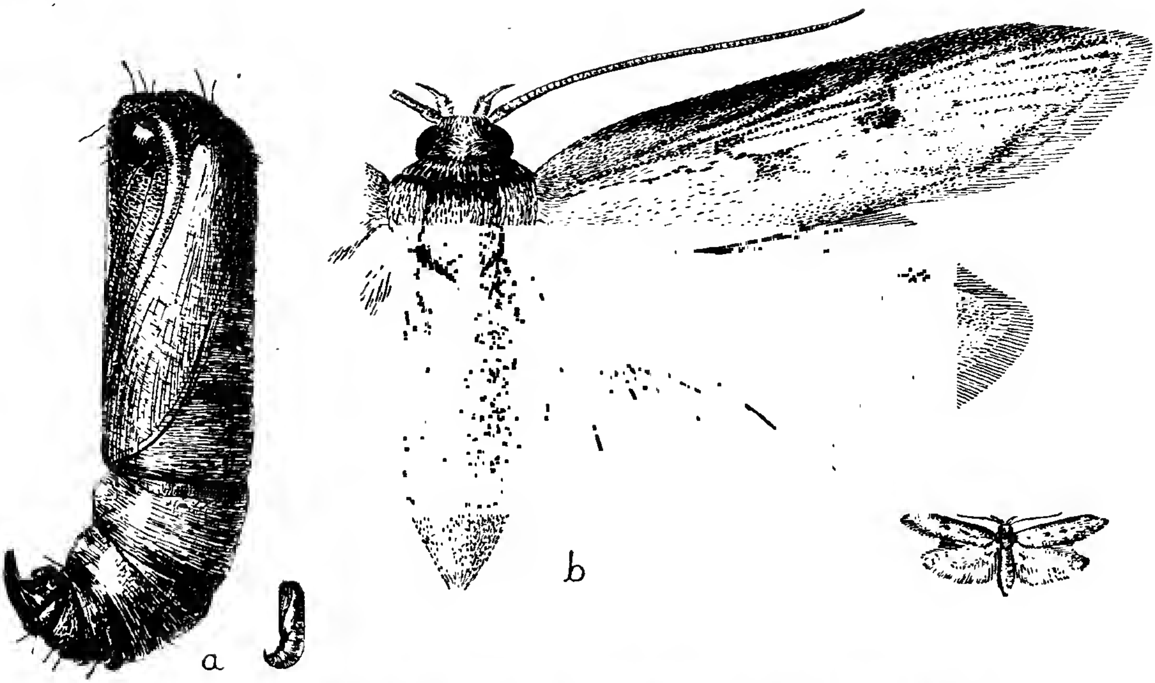


Fig. 1.—*a*, pupa - *b*, Moth (magnified ; the smaller figures show the natural sizes).

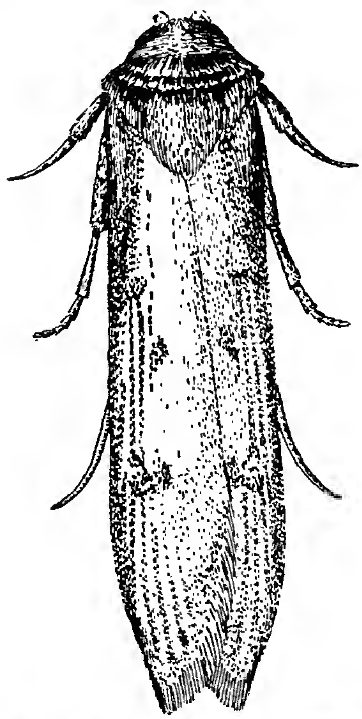


Fig. 2.—Moth, resting position (magnified).

Procometis trochala, Meyr.

Key to Pupæ of Borers.

1	Larval tubercles (bases of hairs) converted into spines on the body of the pupa	2
	Without such spines on pupa	3
2	The protuberant part of the hind end of pupa is broader than long and has two indentations on the tip, each indentation having in it a short spine surmounted with a hair	C. S. 1835
	The protuberant part of the hind end of pupa is conical and has no spines of any kind . . .	*Chilo torrentellus.*
3	Without ridges or hooks or apparent roughness on 7th Abdominal segment	4
	Pupa with such	5
4	The hind end having distinct spines. . . .	C. S. 1677
	The hind end having no spine. The dorsal part of the hind end is protruded and the protruded part has a clean rounded margin	*Crambus corticellus.*
5	With complete circle of ridges spines or roughness on 7th abdominal segment	6
	With incomplete circle as above	7
6	Circle composed of distinct and separate spines .	(C. S. 1610) *Argyria tumidicostalis.*
	Circle of flattened ringlike ridges more or less joined to one another	(C. S. 1560). *Diatræa auricilia*
7	Incomplete circle of distinct spines	C. S. 1674.
	Incomplete circle of roughness without distinct spines	8
8	Dorsal half of anal end with six spines in two groups of three triangularly arranged	*Chilo simplex.*
	Dorsal half of anal end with four spines	9
9	The spines situated on dorsal margin and pointing more or less backwards (dorsally)	10
	The spines situated on tip and pointing posteriorly .	*Diatræa venosata.*
10	The ridge of roughness on 7th abdominal segment extending towards the ventral surface beyond the spiracles	C. S. 1769.
	Extending up to the spiracles	C. S. 1795.
	Not extending up to the spiracles	C. S. 1831.

Life Histories of the Borers.

Pachydiplosis oryzæ.

This is a small mosquito-like fly the larva of which feeds inside rice plants and causes the growth of a long tubelike gall in place of the stem. The stem being thus destroyed, the affected plants do not produce any ear. This disease has been referred to in the first paper and a coloured plate has been given there showing galls and the different stages of the fly. The disease has been known to exist in Madras, Western Bengal and Bihar and Orissa for a very long time. It is, however, only recently that its real nature and the agency causing it

have come to right. It is known under various names, all descriptive of the outward symptom of the disease. Some of these names are given below with the localities where they are prevalent.

In Tamil districts of Madras :—
Anaikombu (Elephant tusk).
Thandeethu (bearing of earless stalks).

In Telugu districts of Madras :—
Kodu.
Koyyala Tegulu (stick disease).

In South-Kanara district—
Kane.

In parts of Orissa (Angul, Cuttack) :—
Thenga (rod).
Penkalia (flute shaped).
Kalia (cigar-shaped).
Sunda (Tusk ; rod).

In Chota Nagpur in Bihar and Orissa :—
Auræia.
Bhenku.
Khorka (stick).
Sanhra (twining male, as no ear is produced ; Sanhr =bull).

In parts of West Bengal (Burdwan and Bankura)—
Bhènpu or *Bhepu* (pipe).
Khorka (stick).
Khorka-mara or *Khorkadhara* (affected with *Khorka* disease).

The first authentic record of the occurrence of this disease was made in October 1880, when the Magistrate of Monghyr in Bihar reported serious injury to paddy in a particular part of the district. (*Ind. Mus. Notes,* Vol. I, p. 103). The next record is in the report of the Agricultural Chemist, Mysore State, for 1901-02. In that year it occurred in a large area several square miles in extent in Mysore district and the attack was a very severe one causing enormous aggregate loss to the *raiyats.*

Since 1913 it has been reported from various places in Bengal, Bihar and Orissa and Madras. As a result of the attention paid to it the following facts have been gathered.

The Fly appears in August and September and sometimes as late as October. It may be present earlier in the season but it is about this time that it occurs in sufficient numbers to attract attention and in some years in large numbers, large enough to cause serious damage.

Generally speaking, young transplants and young tillers of earlier transplanted and therefore advanced plants are attacked. Usually the damage is severe in the former and when the transplanting operations become late as much as 50 to 75 per cent. of the plants may be affected. Also plants standing in water are more liable to be attacked than those in waterless lands.

The fly lays reddish elongated tubular eggs about 0·5 mm. long and about 0·125 mm. thick, with rounded ends " on the hairs of the ligules or on the lower surface of the basal parts of leaves and rarely also on their upper surface. The tiny young larvæ creep down between the leaf-sheaths till they reach the growing point of the apical or the side buds. On entering the interior of the buds, they seem to lacerate their tender tissues and feed on their nutritious juices. Whether by actual feeding or continual irrigation, an oval chamber is formed round the maggot in the tissues of the growing point. Further normal apical growth being stopped all the nutrition is directed to the walls of this chamber which elongates like a normal internode (forming the characteristic long gall). By the time the outgrowth begins to be visible, the maggot will generally have turned into a pupa and in about six days will be ready to emerge as a fly. When about to transform, the pupa with the help of the dorsal spines of its abdominal segments wriggles up the hollow tube and boring a hole at the tip with its front spines, partially projects out. The adult now emerges and flies away, leaving the empty pupal skin at the tip of the hollow shoots " (Y. Ramachandra Rao). Each female is capable of laying about 100 eggs. The time occupied from the time of oviposition till the emergence of the fly seems to be about two to three weeks.

It is not known how the fly passes the rest of the year or whether it breeds in any other plant than paddy. In 1917 Rao Sahib Y. Ramachandra Rao published his observations on galls occurring in various grasses in Madras. (*Proc. Asiatic Soc. Bengal, New Series,* Vol. XIII, No. 5, pp. 299-306, 28th December 1917—Reprinted in *Pusa Bull. No. 89, Second Hundred Notes on Indian Insects*). He noticed in October 1916 similar silver shoots as in rice in *Panicum staninum*, an aquatic plant common at Samalkota along canals, in shallow tanks and along water channels in wet lands. The fly reared from this gall was found to be identical with the rice gall fly (*Pachydiplosis oryzæ*). At Coimbatore however this grass did not show any gall formation although the rice gall fly was common there. Similar silver shoots were also observed by him at Samalkota in wild varieties of *Paspalum scrobiculatum* and *Oryza sativa*, but no fly could be reared from them on account of heavy parasitization. The question of alternative foodplants and

behaviour of the fly throughout the year still remains unsolved and obscure.

As regards control we have got the following facts :—

1. In 1915 this pest occurred extensively in the neighbourhood of Ranchi and in Khunti Sub-division of the Ranchi district. Mr. A. C Dobbs, Deputy Director of Agriculture, in charge of this area, had an opportunity of keeping this area under his observation throughout the season. In the middle of August and early September he reported extensive damage. In the second week of September the writer visited the affected area near Ranchi and found that certain kinds of rice and certain fields newly transplanted were affected to the extent of about 5 to 50 per cent. In November Mr. Dobbs reported as follows :— "The crop at Khunti and here (Ranchi) have made a remarkable recovery owing to a good *hathia* (rain) and it looks as if the effect of the attack is temporary and more or less confined to the shoots attacked. On the return of favourable conditions the plants throw out side shoots and make a more or less complete recovery."

In rice, sugarcane and allied plants whenever a growing point is damaged, further growth is stopped. But if the conditions be favourable the plants always make an attempt to compensate the loss by throwing up side-shoots and tillers. In Bengal, the cultivators apply *Khari nun* (crude sodium sulphate) in fields affected by this disease and they assert that it checks the disease. The explanation seems to be that the growth of the plants is stimulated and recovery takes place owing to the development of tillers and side-shoots.

2. During the outbreak of 1915 in the Ranchi district it was observed that broad-casted paddy sown in April, May or June, and therefore much advanced in growth at the time of the writer's visit in the second week of September, was practically immune (their young side-shoots being affected to a small extent) compared with the late-transplanted young seedlings. Transplantation was still going on at the time. Therefore it seems that carrying out of the transplanting operations early in the season would be a preventive but this is entirely dependent upon the prevalence or otherwise of favourable climatic conditions.

3. There is a minute black parasitic wasp (*Platygaster oryzæ*) which seems to keep the pest in check. In some years however and in some localities owing to unknown reasons the number of the parasites decreases, resulting in a corresponding increase in the number of the fly with more damage to paddy as a consequence. At Ranchi in the second week of September 1915 only about one per cent. of the maggots was observed to be parasitized. In Madras in 1913 and again in 1914 (years of normal slight infestation) the maggots were parasitized to such an

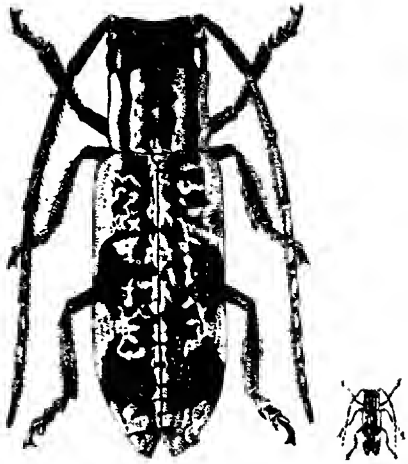


Fig. 1.—*Lychrosis zebrinus.* **Beetle (Magnified ; the smaller figure shows the natural size).**

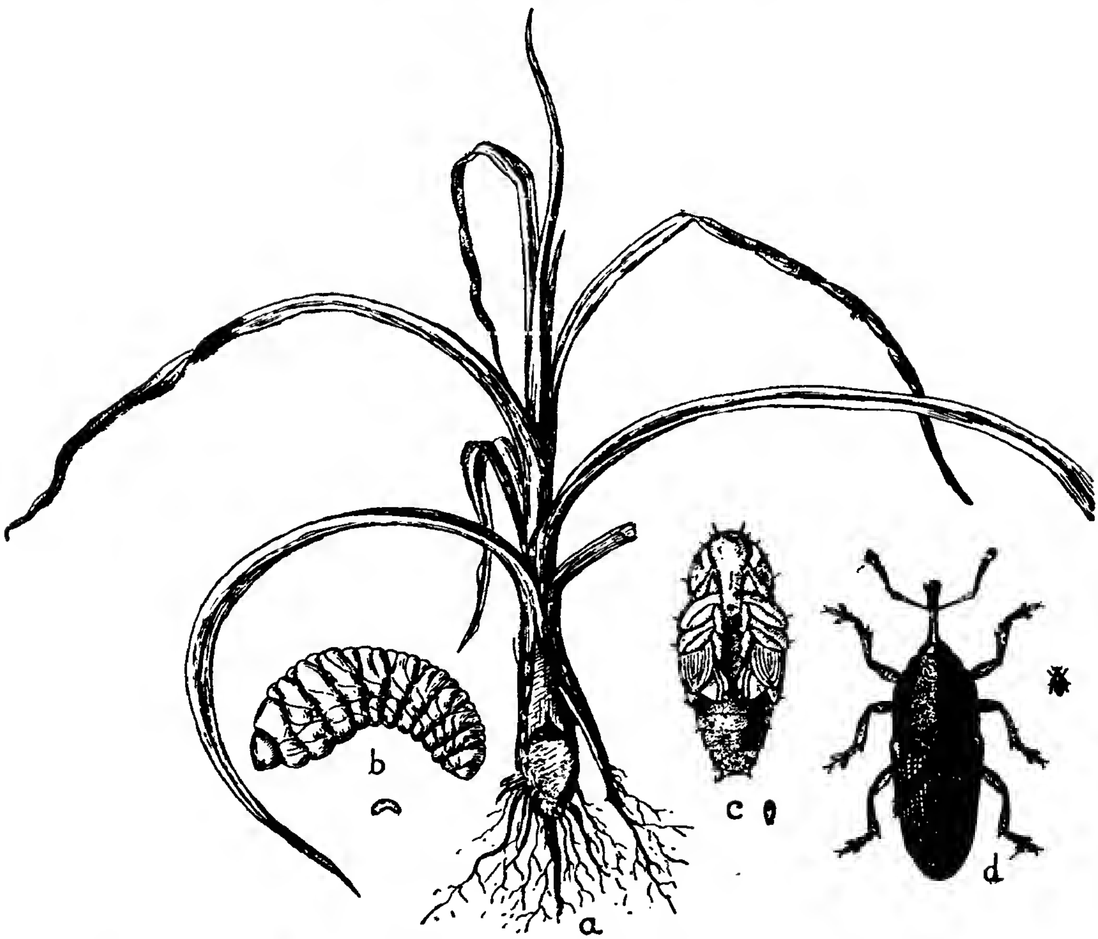


Fig. 2.—Weevil Borer (C.S. 2044) ; *a,* **attacked** *Mootha* **plant ;** *b,* **larva ;** *c,* **pupa ;** *d,* **beetle (***b,c,d,* **magnified, the smaller figures showing the natural sizes).**

enormous extent that it was difficult to rear out adult flies. About 20 to 30 grubs of this parasite occur in the body of a single maggot. They devour the contents of the body of the maggot by the time the latter is full grown and pupate in brownish cocoons formed in a mass inside the skin of their host. This cocoon mass is observed on splitting open the hollow gall.

4. The adult flies are attracted to bright powerful lights. No flies were attracted at Ranchi to a light trap improvised with an ordinary hurricane lantern and new shining pieces of tin used as reflectors. In Madras, on 25th October 1915, 27 flies (mostly females) were recorded to have come to the Aladdin Incandescant Lamp and between 28th October and 2nd November 1915, 96 females and 11 males were attracted to what is called a P. W. D. lamp.

Taking the above facts into consideration it is clear that the best remedy for the cultivator to adopt is to try to improve the conditions by the application of manures, irrigation when necessaiy and other means, so as to bring about a healthy and vigorous growth of side shoots and tillers.

Lychrosis zebrinus, Fb.

(Plate XVIII, fig. 1.)

Foodplant—*Batri* (*Saccharum spontaneum batri*).

Hibernating larvæ were collected in February 1920. One pupated in May and emerged on 16th May 1920. The larva resembles that of the Lamiad borer (C. S. 1814) described in the first paper. (*Proc. Third Entl. Meeting*, p. 372).

The weevil borer (C. S. 1397 and 2044).

(Plate XVIII, fig. 2.)

Foodplant—*Mootha* (*Cyperus rotundus*).

It has been referred to in the first paper. (*Proc. Third Entl.* Meeting, p. 373). The remarks made under *Bactra truculenta* at page 126 of this volume regarding the foodplant should be seen. This insect has not been found in any other food plant.

Eggs are apparently deposited inside the stem near the root-stock. The grubs are found right at the root of the stem at its junction with the root-stock. They do not work up the stem but gnaw a large cavity at this place thus cutting across the base of almost all the leaves of the inner whorls which droop, turn yellow from their spices and ultimately wither. The cavity the grubs gnaw is filled with black excreta. Sometimes the grubs are observed to bore into the root-stocks.

Pupation takes place inside the stem or rootstock and rarely in the ground. The periods of the different stages are not definitely known. The life-cycle seems to be completed in about three to four weeks.

The fullgrown grub is about 4 mm. long and about 1·5 mm. across the thoracic region from which the body tapers gradually both ways. The head is much smaller than the prothorax, pale yellow in colour and glossy. The body is subcylindrical in shape being slightly compressed in the dorsoventral plane. The skin is wrinkled and the segments are hardly distinguishable. The colour of the body is pale yellow with a brownish tinge which disappears before pupation. On each side a white tracheal tube is visible under the skin. The pupa is about 3 mm. long and of the ordinary Curculionid type. It is yellowish white in colour. The weevil is black.

Sesamia inferens.

To the foodplants Lemon grass is added.

C. S. 1666.

Katra (*Andropogon squarrosus*) is added to the foodplants.

Heterographis sp. (C. S. 1700).

The Phycitid borer of tender maize cob referred to at page 378 of the first paper is *Heterographis* sp. It has not been observed to occur again.

The Phycitid Borer. (C. S. 1837 and 2060).

(Plate XIX, fig. 1.)

Foodplants—*Marua* (*Eleusine coracana*).
Rice (*Oryza sativa*).

This borer has been referred to in the first paper (*Proc. Third Entl. Meeting*, p. 378) as occurring in *Eleusine coracana* but it has since been observed in rice stems also. It however never appeared in large numbers and from its seasonal history and its habits it appears that it will most probably never rise to the rank of a major pest. The caterpillars have been observed to rest in the Insectary from September to the end of June and they have been collected from the fields in July and August, moths being reared in the Insectary between 8th August and 6th September. Out of a lot of seven caterpillars collected in the latter half of August three developed into moths between 28th August and 6th September and the others rested as stated above, till the end of June

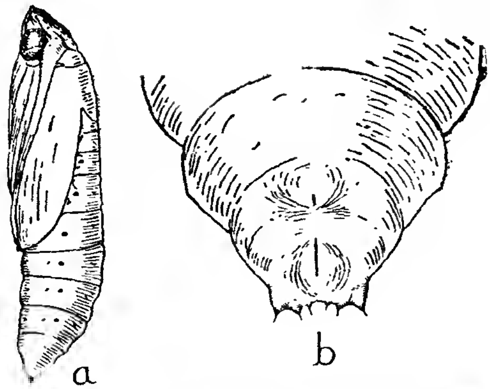


Fig. 1.—Phycitid Borer (C.S. 2060) ; *a*, pupa (×7) ; *b*, ventral view of hinder end of pupa, more highly magnified.

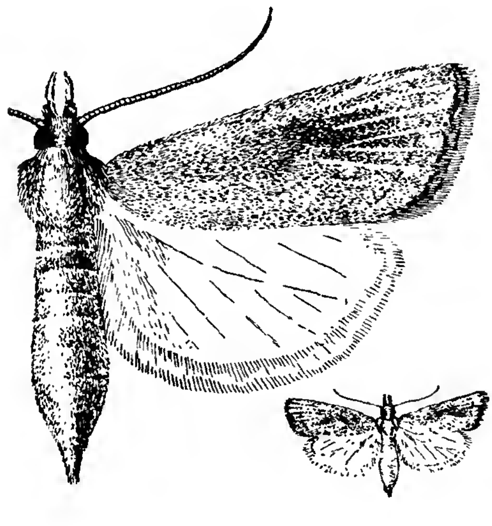


Fig. 2.—*Diatræa auricilia* (magnified ; the smaller figure shows the natural size).

next year. They did not mind the dry conditions prevalent during the winter and the hot weather. Therefore the insect appears to have only one generation in the year, some probably having two.

The caterpillars are observed to enter the stem near the base through a hole gnawed on the side and then bore down towards the root. The result of course is dead heart. When full-grown the larva usually leaves the stem and pupates in a tubelike silken cocoon formed under the earth and among the roots of the plants in the clump. The cocoon goes down vertically or obliquely to a depth of about three-fourths of an inch, its mouth remaining open at the surface of the soil so as to enable the moth to emerge without difficulty. The pupa lies at the closed bottom end with its head turned towards the opening. The pupal period is about nine days.

The caterpillars cannot attack paddy in submerged lands. They have been observed to occur only in dry land paddy and the other food-plant observed, *viz.*, *marua* (*Eleusine coracana*) is also a dry land crop. Their habit of feeding and pupating underground precludes their occurence in submerged crops.

A full-grown larva measures about 12 mm. in length and is about 2 mm. across the mesothorax which is the broadest part from which the body tapers gradually though slightly towards both extremities. The shape is cylindrical and the segments clearly distinguished. The head is yellow, hardly glossy, has brown mouthparts and is partly retractile into the prothorax. The body is uniform creamy white without any warts. The meso- and meta-thoracic segments are divided into three subsegments of which the middle one is the largest. The eight abdominal segments are divided into two subsegments of which the anterior one is larger than the posterior one. The hairs are thin, whitish. The spiracles are round, yellowish with a narrow brown rim. The hooklets on abdominal prolegs are arranged in an elongated oval outline, the inner end of this outline being narrower than the outer end. There are five pairs of short but equally developed prolegs.

The pupa is about 8 mm. long and about 2 mm. thick across the thorax, cylindrical in shape, tapering at the head end as well as hindwards. The head end is somewhat protruded, the protruded part being compressed in the lateral plane and having a raised ridge in the middorsal as well as in the midventral region. The abdominal segments are devoid of spines or ridges or roughnesses. The spiracles are broadly oval, rather large, brown spots under which a tracheal tube is visible in the abdominal region. The hind end has six pyramid-shaped papillæ arranged in a straight row in the lateral plane. The two outside papillæ are large and the others diminish in size inwards. Each of them is

tipped with a short hair. The colour is creamy white, the protuberance on the head and the anal papillæ turning brownish as the pupa matures

Saluria inficita, Wlk.

Foodplant—*Ragi or Marua* (*Eleusine coracana*).

This borer is mentioned in *South Indian Insects*, pp. 427-428, where an illustration is given. It was observed as a minor pest on the Central Farm at Coimbatore in August and September in 1908, 1909 and 1913. It has not so far been observed in North India. It is allied to the previous species.

The following note on the lifehistory appears in the above-mentioned publication : " The larva is moderately stoutly built, the prothoracic segment is large, the next two segments short but projecting ; in colour it is pure creamy white, the head yellowish tinged with blackish around the mouthparts ; there are a few short white inconspicuous hairs on all segments. It bores into the stem of the foodplant low down at about or just above ground-level and pupates in the stem or emerges and pupates in a small chamber excavated in the soil. The female moths are attracted to light at night."

Scirpophaga xanthogastrella.

Ikri (*Saccharum fuscum*) is to be added to the list of foodplants.

Procometis trochala, Meyr. (Plate XVII.)

Katra (*Andropogon squarrosus*) is to be added to the list of foodplants. The caterpillars webbed up the bases of the plants in the stool at the surface of the soil and nibbled the surfaces.

Raphimetopus (*Anerastia*) *ablutella* has not been observed to occur during the last two years.

Chilo simplex.

Add to foodplants *Coix lachryma-jobi* var. *aquatica*.

The larva was once found boring *Chichera* (*Luffa* sp.) fruit at Pusa in July.

In Burma I did not come across *Chilo simplex* during my search in the cold weather of 1920-21.

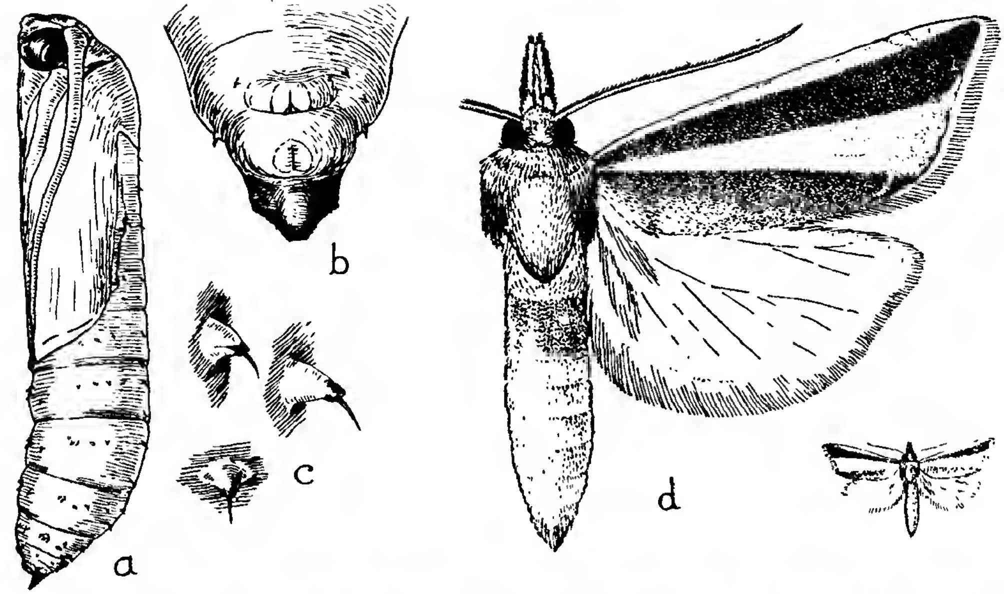


Fig. 1.—*a*, Pupa (×5); *b*, ventral view of hinder end of pupa, more highly magnified; *c*, details of spines on pupa; *d*, moth, natural size and magnified.

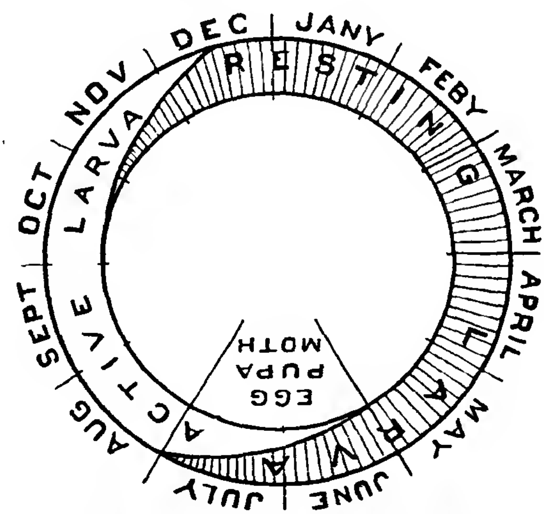


Fig. 2.—Annual life-cycle at Pusa.

Chilo torrentellus.

Diatraea venosata, Wlk.

A notable observation with regard to this borer is that it was found in December 1919 to occur as a regular pest of sugarcane at Cuttack where no *juar* (*Andropogon sorghum*) is grown and hardly any *Saccharum spontaneum* occurs. At Pusa, where there are extensive tracts under *juar* and *S. spontaneum*, *D. venosata* occurs very commonly in *S. spontaneum* and *juar* but very rarely in sugarcane.

Chilo torrentellus.

(Plate XX.)

Foodplant—*Rarhi* and *Batri* (*Saccharum sponta eum*).

It has been referred to as a Pyralid Borer (Pl. 64, fig. 1) in the first paper (*Proc. Third Entl. Meeting*, p. 393). The stems are bored in their central part and converted into hollow tubes. When the larva bores near the top the heart shoot dies and dries. Otherwise there is hardly any prominent external symptom. The caterpillars are found in very large numbers. They may be looked for in thin reedlike varieties of sugarcane, although none has been observed in this plant yet.

The young and full-grown caterpillars resemble one another in appearance. The full-grown larva is about 35 mm. long when fully stretched. The mesothorax is thicker than other segments and measures about 3·5 mm. across and from this segment the body tapers both ways slightly and gradually. The shape is cylindrical but looks slightly compressed in the dorsoventral plane. The head is yellow, glossy, with the buccal region and appendages dark brown. The prothoracic shield is not prominent. The thoracic segments have a tinge of the same colour as the head. The segments of the body are not very prominently distinguished. The skin of the whole body has a shiny appearance and is naked, the primary hairs being minute and black. The spiracles are elongated oval, wholly light-brown with a narrow dark rim. Along the spiracles a tracheal tube is faintly visible under the skin. The hooklets on the five pairs of short but equally developed prolegs form complete circles. Before pupation the larva gnaws a hole on the side of the stem, the mouth of the hole being kept closed by a thin membrane of the bark. Pupation takes place inside the bored stem near this hole in a sort of a cocoon formed with chewed particles spun up with silk. The pupa is about 14 mm. long by about 2·75 mm. thick, cylindrical. The head end is somewhat protruded forwards. The dorsal part of the hind end is protruded into a thick broad wedge-shaped process which possesses no spines of any kind. The 4th to 9th abdo-

minal segments have spines in places corresponding to the primary tubercles of the larva. The spines are broad and have a needle-like short thin process arising slightly below the tip. The colour is yellow. The spiny pupa is liable to be confused with that of C. S. 1835 (Plate XX fig. 1*a*) but can be distinguished by looking at the hind end.

The moth is quite different from that of all the other borers, the forewings being white with a broad blackish longitudinal marking in the middle.

The seasonal history has been graphically shown in the chart. (Plate XX fig. 2). The moths appear in June, July and August, when eggs are laid. The egg has not been observed. Young caterpillars occur about this time and feed till about November when hibernation commences inside the bored stems. After hibernation and partial aestivation, pupation commences in May and moths appear in June. In the Insectary caterpillars have been observed to rest till about the middle of October and then die. This prolonged rest may indicate that probably some larvæ do not pupate till the second year. Or it might be due to Insectary conditions.

Hypsotropa tenuinervella. (C. S. 1920 and 2016).

(Plate XXI.)

Foodplant—*Katra* (*Andropogon squarrosus*).

The seasonal history is graphically shown on Plate XXI, fig. 2 The larvæ hibernate from about October to about March and are not affected by dry conditions. In the Insectary moths were observed to emerge up to 9th October 1919 before the winter and on the 14th March 1920 after the winter.

The caterpillars are true borers. They are of three different colours. Some are red, some are cream coloured and some pale yellow, although morphologically they are the same. A full-grown caterpillar is about 15 mm. when stretched and about 2·5 mm. thick. The head is compressed in the dorso-ventral plane, brown and glossy. The prothoracic shield is not very distinct, glossy pale brownish-yellow. The segments of the body are divided into two subsegments, the anterior subsegment being large and the posterior small. The hairs are thin, brownish. The spiracles are broadly oval, not exactly round, pale yellow with a thin brown rim. The five pairs of prolegs are equally developed, the hooklets on them being in elongated oval outline.

All turn pale yellow before pupation.

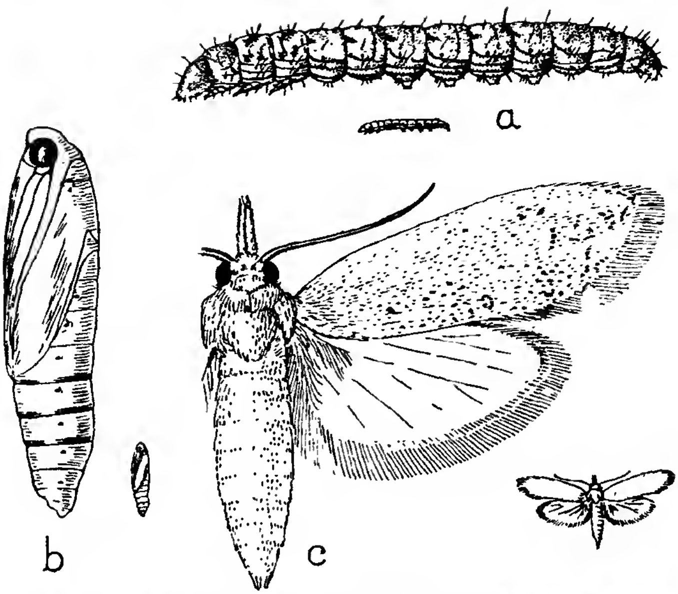


Fig. 1.—*a*, larva ; *b*, pupa ; *c*, moth ; all ×5 and natural sizes.

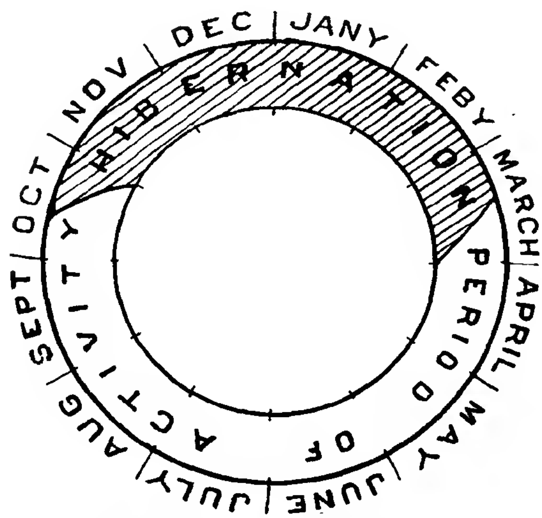


Fig. 2.—Annual life-cycle at Pusa.

Hypsotropa tenuinervella.

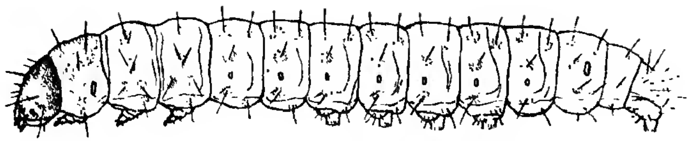


Fig. 1.—Larva (magnified).

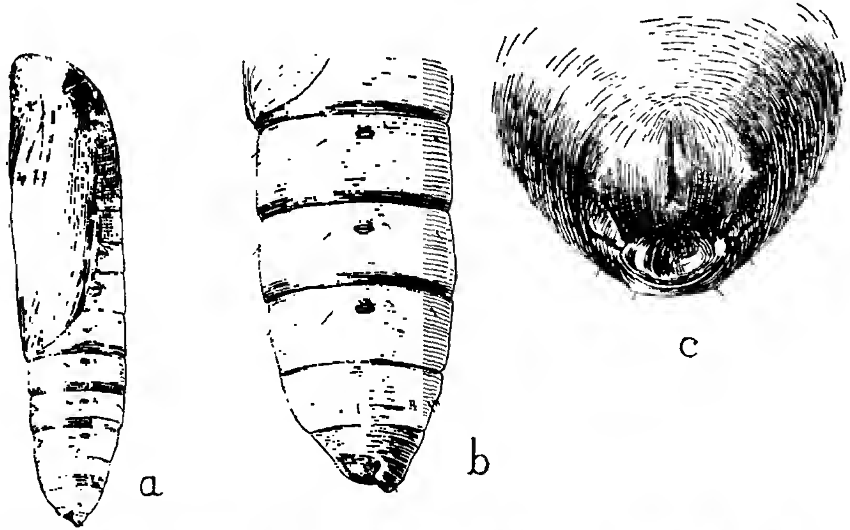


Fig. 2.—*a*, pupa (magnified) ; *b*, hinder-end of pupa, more highly magnified ; *c*, ventral view of hinder-end of pupa, still more highly magnified.

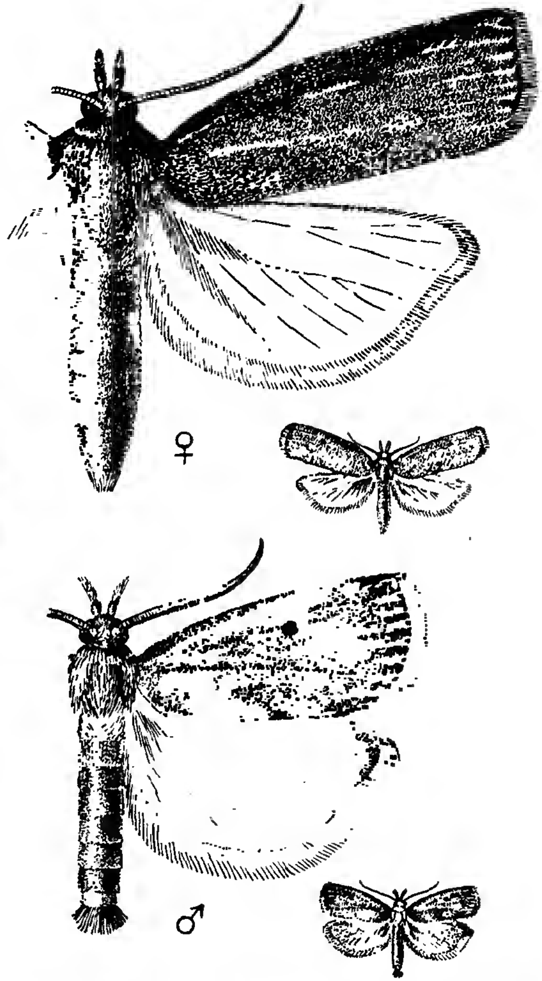


Fig. 3.—Moths (female above and male below) natural sizes and magnified (×4).

Crambus corticellus.

Pupation takes inside bored stems in silken cocoons with pellets of excreta and bits of leaf webbed on its surface. One end of the cocoon communicates with the hole of exit the larva prepares for the future moth on the side of the stem, the mouth of the hole being closed with the thin epidermal layer of the leaf sheath.

Pupa is about 11 mm. long by about 2·5 mm. across the thoracic region which is slightly compressed in the dorsoventral plane. The abdominal region is cylindrical and tapering hindwards almost to a point. The head end is tapering, with an indistinct longitudinal ridge on its ventral side. The spiracles are elongated oval, brown-rimmed. The colour is yellow with a brownish tinge at the anterior part.

Crambus corticellus, Hmpsn.

(Plate XXII.)

Foodplant—*Scirpus corymbosus.*

This insect was observed to bore the sedge named above at Nagpur by Mr. J. L. Khare. The caterpillars were collected in January, April and May. There are specimens in the Pusa collection taken at Pusa almost throughout the year. Apparently the insect is active throughout the year.

A larva, about half-grown and preserved in spirit, has a glossy brown head. The prothoracic shield is of the same colour as but paler than the head. Warts on the segments large, roundish and of the same colour as the prothoracic shield. The general colour of the body is pale yellow. The prothoracic and the eighth abdominal pairs of spiracles are much larger than the others. All the spiracles elongated oval, a brown rim enclosing a clear space. The hooklets on prolegs are arranged in a complete circle.

Pupa, about 14 mm. long and about 3 mm. thick, cylindrical and brownish yellow in colour. The abdominal segments possess no spines or roughnesses. The dorsal part of the hind end is protruded to some extent and the protruded part has a rounded margin, is flat on the ventral and convex on the dorsal side and possesses no spines of any kind.

Bactra truculenta, Meyr.

(Plate XXIII, fig. 1.)

Foodplant—*Mootha* (*Cyperus rotundus*).

This insect has been referred to in the first paper (*Proc. Third Entl. Meeting*, p. 394). It has not been observed to occur in any other

plant. *Mootha* is a troublesome weed in many parts of the country and it takes several years of careful uprooting along with the root-stocks to eradicate it from lands newly brought under cultivation. Although it serves partly as food for cattle, there are some varieties of it which are not liked by cattle. It grows very profusely and luxuriantly and the influence of this borer aided by the weevil borer referred to at page 119 of this volume seems to be very small as a check.

In the neighbourhood of Pusa this insect is observed to be active throughout the year. The caterpillars do not bore down from the top but effect their entrance into the centre of the leaf-bundle or into the stem in advanced plants, through the lower leaf-sheaths and tunnel up and down the central region but never enter the root-stock. The result of course is dead-heart in young plants but in the fully developed stem the effect is hardly apparent externally. Pupation takes place inside the stem of the affected plants in an elongated silken cocoon formed lining either the tunnel or the outer leaf-sheaths, the moth emerging after about five days. Ordinarily the life-cycle seems to be completed within about three weeks.

Full-grown larvæ measure about 12 to 15 mm. in length and about 1·5 mm. in thickness across the anterior part of the body which tapers gradually and slightly hindwards. They have a slender, longish and dorsoventrally compressed appearance. The head is slightly smaller than the prothorax which has a distinct shield of the same colour as the head. Spiracles are round, a narrow brown or black rim enclosing a clear space. Running along and connecting the spiracles a tracheal tube is more or less visible under the skin. There are five pairs of equally developed prolegs with hooklets arranged in a circle. In coloration the larvæ vary a good deal, the following three types occurring commonly :—(1) Body pale yellow with the mesothorax, metathorax and to a less extent the first two abdominal segments purplish and head brownish yellow. (2) Body green with the mesothorax, metathorax and the first two abdominal segments smoky or dusky and head pale yellow with a greenish tinge. (3) Body uniform pale yellow with dark grey or black head. Green larvæ are the commonest of all.

The pupa is about 5 to 7 mm. long, cylindrical, tapering slightly towards hind end. Each of the third to eighth abdominal segments has two transverse rows of spines on the dorsal side, the row at the anterior part consisting of straight posteriorly directed spines and that at the posterior part of very small spines. The ninth abdominal segment has a single row of large spines the tips of all or some of which are curved up anteriorly. The hind end is rounded and has a pair of small pyramidal papillæ surrounded with hairs. The colour of the

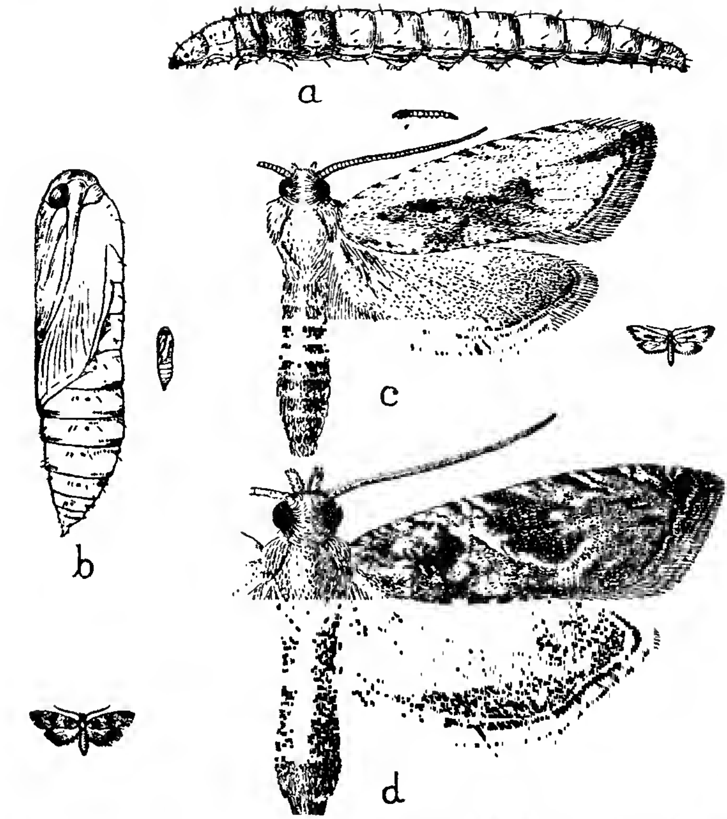


Fig. 1.—*Bactra truculenta* ; *a*, larva ; *b*, pupa ; *c*, *d*, moths, all natural sizes and magnified (×8).

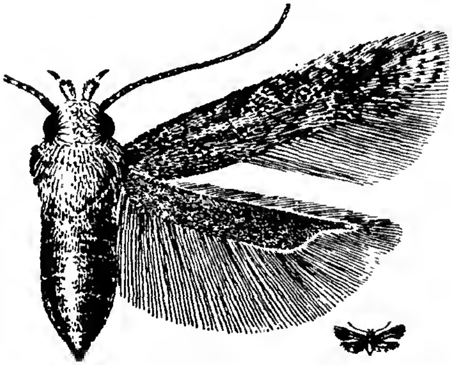


Fig. 2.—*Ephysteris chersæa*, Moth, natural size and magnified (×11).

Fig. 3.—*Rhyssemus germanus*, natural size and magnified (×13).

pupæ too varies. The pupæ of the green larvæ are green with the head, thorax and wing regions brownish yellow. Other pupæ are pale brownish yellow turning in the end grey brown with the wing regions black.

The moths too are variable in colour. Some are grey or yellowish with longitudinal dark marking along the middle of the forewing. Others have the entire surface of the forewing covered with blackish patches.

Ephysteris chersæa, Meyr. (C. S. 2046).

(Plate XXIII, fig. 2.)

Food plants Rice (*Oryza sativa*), Pusa.
China (*Panicum miliaceum*), Pusa.
Juar (*Andropogon sorghum*) stubbles, Coimbatore.

The caterpillars occurred at Pusa in small numbers. They were boring *China* stems in June and rice stems in July. At Coimbatore they were reared from *juar* stubbles. Moths were collected by Mr. T. Bainbrigge Fletcher at Abbottabad in June and they were also collected at Purnea. This insect has not yet been observed to occur in sufficiently large numbers to justify its inclusion in the list of pests.

The full-grown larva is about 6 mm. long and cylindrical in shape. The head is reddish brown. The prothorax has a blackish shield divided longitudinally in the middle. The general colour of the body is pale yellow with a broad dark grey band on each segment. Five pairs of equally developed prolegs are present.

The pupa is about 4 mm. long, cylindrical in shape and tapering hindwards. The hind end is rounded and has a few short thin circinate hairs at its dorsal part. The colour is yellow brown. In one case the larva left the stem and pupated underground.

Oryctes rhinoceros.

This beetle lays eggs in rotting masses of leaves, straw or grass, rotting stems of coconut and other palms, moist rotting wood or sawdust and in manure pits. The grubs feed on the decomposing vegetable matter. The adult beetles however fly at night and bore into soft crowns of Coconut, Date, Toddy and other palms (except, so far as known, Betel Nut palms). As they occur in large numbers they bring about the death of many trees, thus constituting a serious pest especially of coconut palms. They are also known to bore American Aloes and

occasionally sugarcane. The photograph, reproduced as fig. 69 of *South Indian Insects*, records its occurrence on sugarcane at Coimbatore in October 1913 and shows the characteristic chewing of the beetle. They may occasionally be expected on thick varieties of sugarcane but will probably never prove a regular pest of this crop. [This insect has, however, occurred in the Malay States as a pest of sugarcane. T. B. F.]

So far as is known this insect passes through a single generation in the year. The egg and pupal stages are short, lasting only for about one-and-a-half to two weeks, the rest of the long cycle being passed in larval state. Adult beetles have been reported from different localities from about June to December or even January. Beetles emerged in the Pusa Insectary from grubs collected from outside between May and August. May to August probably represents the time of emergence of the adults which seem to be able to live for long periods under favourable conditions and are therefore reported to occur even in December or January. Variations apparently occur in the lifehistory according to varying conditions of different localities. It is not known whether there is a definite period of oviposition or whether eggs are deposited throughout the period the adults live.

Apogonia proxima, Waterh.

A pupa and many adults were collected at Pusa among *Saccharum spontaneum* roots in September. The pupa was collected on the 5th September and the beetle emerged from it on the 10th September.

In July, that is, soon after the commencement of the rains, large numbers of this beetle are observed at Pusa to come out at dusk and eat tender leaves of *Ficus religiosa, Vitis trifolia, Capparis* sp., and other plants. They sit in clusters or rather hang on leaves. Males come and mate while females continue eating.

A number of them were collected in July 1914. In confinement they ate leaves and laid eggs freely, which hatched in a week. The eggs are about 1·5 mm. in diametre, round with a smooth surface and creamy white in colour which turns brownish before hatching when the powerful brown mandibles of the embryo are visible through the shell. Attempts at rearing the larvæ failed.

It appears that the beetle passes through only one generation in the course of the year. Apparently the winter and early summer are passed in larval state.

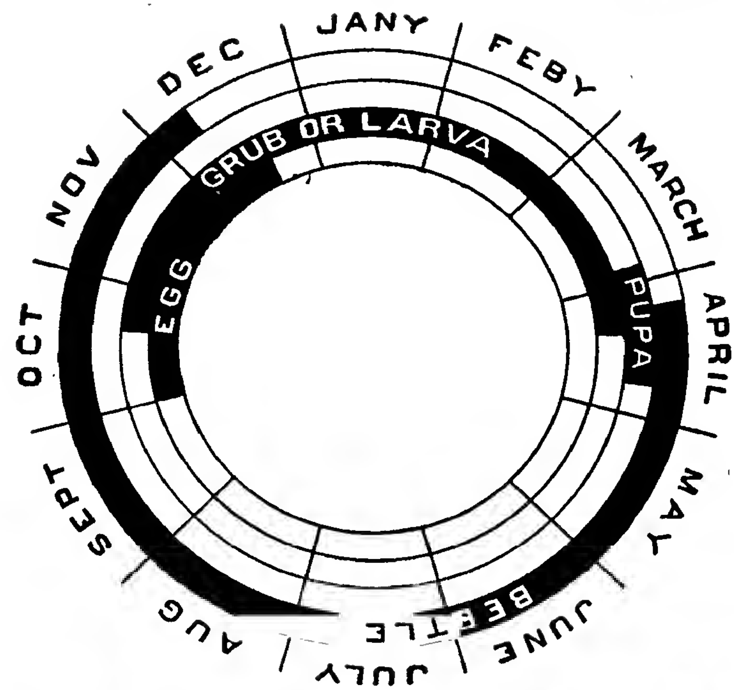


Fig. 1.—*Allissonotum impressicolle.* **Annual life-cycle as observed at Pusa. The black portions indicate the periods of the year when the different stages are found.**

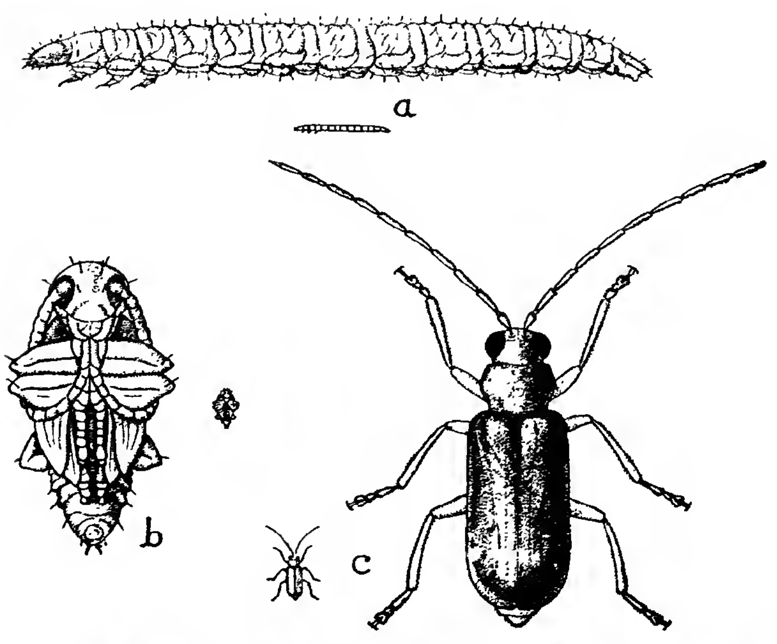


Fig. 2.—C. S. 1640 ; *a,* larva ; *b,* pupa ; *c,* beetle ; all natural sizes and

Rhyssemus germanus (C. S. 1204).

(Plate XXIII, fig. 3.)

Foodplant—Larvæ found among *mootha* (*Cyperus rotundus*) and indigo roots.

This is a small beetle but their small size is more than made up for by the numbers in which they occur. The seasonal history is not understood quite well yet. Probably there are several generations in the hot weather and in the rains, the cold weather being passed in hibernation. In the hot weather from about March to June enormous numbers of the adult beetle fly about in the air at dusk.

Alissonotum impressicolle.

(Plate XXIV, fig. 1.)

The occurrence of this beetle on sugarcane in the Kamrup Farm has been referred to above when dealing with the external agents of damage. The beetles collected in the second week of May 1919 were brought down to Pusa. When collected they were kept with moist earth in a perforated zinc cage and pieces of thick cane stems were supplied as food. They ate voraciously, boring into the pieces of cane. On arrival at the Pusa Insectary, 216 beetles were distributed on 30th May in two glass jars, 108 in each, the jars being filled with moist earth under which sugarcane setts and shoots were placed as food. Between 3rd June and 1st August, 21 beetles were observed to come up to the surface of the earth one or two at a time and at intervals of several days and die there. This was probably due to overcrowding. Otherwise they were resting and did not feed. On 20th October 1919 the jars were searched; 54 beetles were alive and 68 eggs found laid in the earth. Of these 68 eggs :—

2 hatched	22nd October.
3 ,,	24th ,,
2 ,,	30th ,,
2 ,,	2nd November.
2 ,,	3rd ,,
2 ,,	4th ,,
4 ,,	5th ,,
2 ,,	7th ,,

20th-21st October.—35 eggs laid :

1 hatched	31st October	11-20 days; earlier dates probably not correct as some eggs laid previously might have been left over.
2 ,,	2nd November	
4 ,,	4th ,,	
3 ,,	5th ,,	
1 ,,	10th ,,	
	rest spoilt	

21st-23rd October.—16 eggs laid :

7 hatched	7th November	16-20 days ; rest spoilt.
1 ,, ...	8th ,,	
1 ,, ...	11th ,,	

23rd-24th October.—9 eggs—45 beetles alive : 8 A.M.-8 A.M. :

1 hatched	7th November	15-19 days ; rest spoilt.
1 ,, ...	8th ,,	
2 ,, ...	11th ,,	

24th 8 A.M.-25th October 8 A.M.—8 eggs :

1 hatched	8th November	15-17 days.
1 ,, ...	10th ,,	

1 egg apparently unspoilt yet 6th January 1920. Spoilt 13th January 1920.

25th 8 A.M.-26th October 8A M.—10 eggs :

1 hatched . . . . . 11th November 17 days.

1 egg remained apparently unspoilt till 26th December, when it got mouldy.

26th 8 A.M.-27th October 8 A.M.—5 eggs—43 beetles alive :

1 hatched . . . . . 15th November 20 days.

1 egg remained apparently unspoilt till 7th January 1920. Spoilt 27th January 1920.

27th-30th October.—23 eggs—41 beetles alive :

1 hatched	14th November	18,19 days ; rest spoilt.
1 ,, ...	15th ,,	

30th October-2nd November.—26 eggs—33 beetles alive :

1 hatched	17th November	Maximum 20 days, rest spoilt.
2 ,, ...	19th ,,	
1 ,, ...	20th ,,	
1 ,, ...	21st ,,	
2 ,, ...	22nd ,,	

2nd-4th November.—21 eggs—32 beetles alive :

1 hatched . . . . . 21st November.

2 eggs apparently unspoilt 7th January 1920. 1 spoilt 3rd February. 1 spoilt 8th February.

4th-5th November.—10 eggs—30 beetles alive :

1 hatched . . . . . 23rd November. Maximum 18 days. Rest spoilt.

5th-6th November.—6 eggs—29 beetles alive :

2 hatched . . . . . 23rd November. (18 days) rest spoilt.

6th-10th November.—10 eggs—26 beetles alive :

1 hatched . . . . . 26th November.

10th-12th November—22 eggs—26 beetles alive :

1 hatched . . . . . 27th November.

1 ,, ... 29th ,,

12th-14th November—20 eggs—25 beetles alive :

1 hatched	3rd December	1 egg remained in apparently unspoilt condition till 26th December.
1 ,, ...	4th ,,	
1 ,, ...	7th ,,	

14th-17th November—12 eggs—19 beetles alive : all spoilt.
17th-20th November—8 eggs—12 beetles alive :
1 hatched . . . . . 12th December.
1 egg remained in apparently unspoilt condition till 30th December 1919

20th-23rd November—7 eggs—9 beetles alive :
1 hatched . . . . . 17th December.
23rd-26th November—1 egg—4 beetles alive :
It remained in apparently unspoilt condition till 4th January

1st December—No egg—4 beetles alive.
10th December—No egg—1 beetle alive.
14th December—No egg—all the beetles dead.

Twenty-seven grubs, which hatched between 22nd October and 5th November 1919, were placed in one bell-jar with growing maize. On 15th March 1920, only one half-grown was in this jar.

Thirtyone grubs, hatched between 7th November and 12th December, were placed in another jar. On 15th March 1920 eight grubs were living in this jar. One was partly eaten apparently by the other grubs.

31st March 1920—2 pupated.
1 emerged on 10th April
1 ,, ,, 11th ,,

One more found to have pupated on 11th April 1920. It emerged on 21st April.

The grubs hardly did any damage to sugarcane and fed mostly on the manure.

The eggs are white and have a smooth membranous shell. They vary in size. The smallest ones are oval or almost oval in shape measuring about 1·75 mm. in length and about 1·5 mm. the other way. The larger ones are almost round and the largest of them is about 2·5 mm. in diameter. The eggs increase in size with age.

20th October 1919—3 eggs, $1\frac{3}{4}$ mm.... $1\frac{1}{2}$ mm., were kept separately.
27th October 1919—One was spoilt—2 almost round about 2 mm. in diameter.

All eggs do not attain the same size. They vary from about 2 to 2·5 mm. in diameter. The newly-hatched grubs also vary in size, varying in length from about 3·5 to 5 mm. The head is the largest segment. The body tapers gradually from the thoracic region hindwards. The young grubs are like ordinary cockchafer grubs with three pairs of thoracic legs.

The full-fed grub measures, when it walks on a flat surface, about 28 mm. in length. The head is brown yellow and its surface appears minutely pitted under lens ; on the vertex there is a longitudinal slit-like marking. The dorsal regions of the subsegments of the first six abdominal segments have minute bristle-like brown hairs though not

very densely. No other part of the dorsal or ventral surface except the hind end has such hairs. The hind end has a transverse slit; its dorsal margins are clothed in longish brown hairs and its ventral surface has short bristle-like hairs arranged over a space triangular in shape with the vertex of the triangle turned anteriorly. There are a few long hairs scattered on head and body. The spiracles are brown-yellow and crescent shaped; the concave side of the prothoracic spiracles is turned posteriorly and that of all abdominal ones anteriorly. The general colour of the body is pale yellowish white, that of the hinder part being dark. The legs are brownish and each of them has a distinct claw.

Alissonotum piceum.

This most probably has a lifehistory similar to that of *Alissonotum impressicolle*. A few beetles collected in May rested in the Insectary in the adult stage, one living until October, but no eggs were obtained.

Alissonotum simile.

This has probably a lifehistory similar to that of *A. piceum*. A larva collected from sugarcane fields at Kamrup on 20th May developed into a beetle on 16th June.

Xyleborus perforans, Woll.

Foodplants—Sugarcane.
Sal (*Shorea robusta*).
Anogeissus latifolia.
Areca catechu.

"In the course of the last four years during which especial attention has been paid to the insect pests of sugarcane, the Scolytid borer, *Xyleborus perforans*, Woll. (Plate IV), has only been observed once, in December 1919, in a variety of cane called B. 147, which was growing on the Chinsurah Farm. This beetle came into prominence over thirty years ago in connection with the destruction of beer-casks shipped into India and was investigated by W. F. H. Blanford, who considered *X. affinis*, attacking sugarcane in the West Indies, as a variety of *X perforans*. In 1900 a *Xyleborus* was reported as boring sugarcane in Bengal and was considered to be either identical with, or closely allied to, *X. perforans*. In 1892 this beetle formed the subject-matter of a warning letter issued by the Revenue and Agriculture Department of the Government of India, which stated that this pest, notorious in the West Indies as a pest of sugarcane, had already been introduced

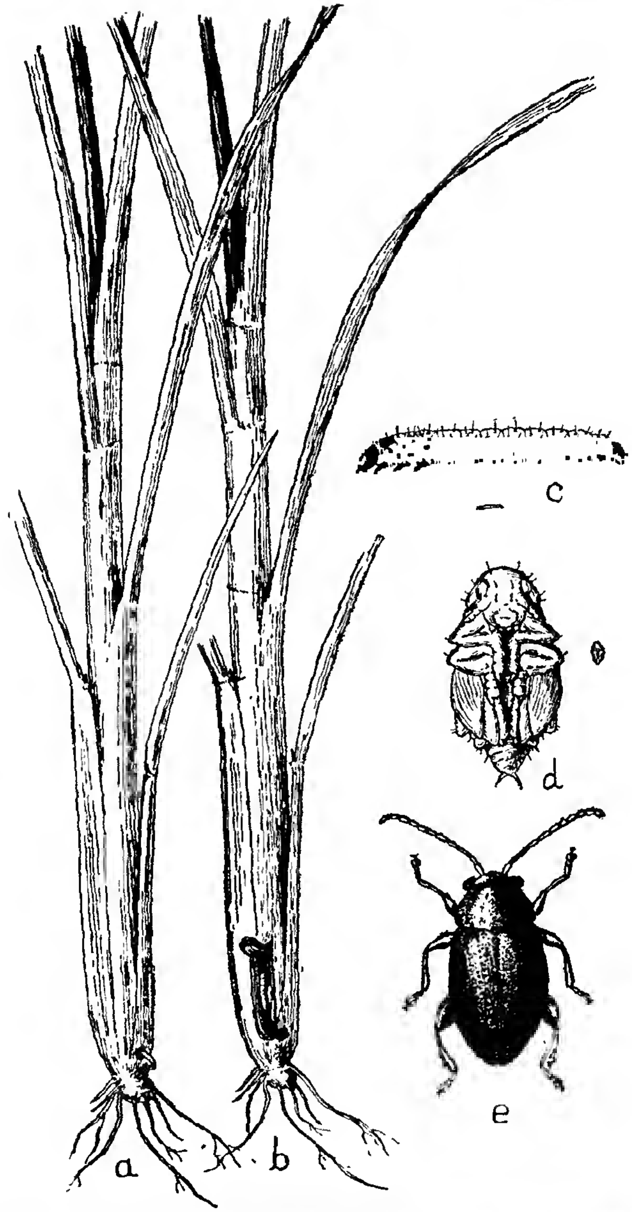


Fig. 1.—*Chætocnema* sp. (C. S. 1923) ; *a*, larva eating into the stem ; *b*, stem cut open to show the larva inside it ; *c*, larva ; *d*, pupa *e*, beetle ; *c*, *d*, *e*. are shown of natural sizes and magnified ($\times 11$)

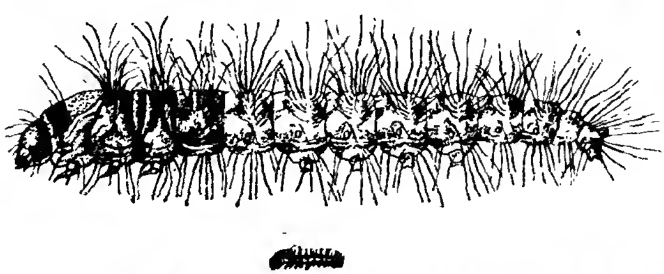


Fig. 2.—C. S. 1696 ; larva, about half grown, natural size and magnified.

into India and therefore advised the adoption of measures against its spread. Its occurrence on the Chinsurah Farm, where it was found breeding in three fully-grown canes growing in a clump, the canes being practically dry and showing characteristic holes emitting dust in their basal joints, indicates that this shot-hole borer may perhaps prove to be an occasional pest of cane, possibly more frequently than has been noted by us. In *Indian Museum Notes*, Vol. V, p. 74, it is recorded as having been found in cane in numerous districts in Bihar and Bengal. *X. perforans* is widely distributed in India and Burma and has been recorded as boring in *sal* (*Shorea robusta*), *Anogeissus latifolia* and *Areca catechu*." (Imperial Entomologist's Annual Report for 1919-20).

The Flea Beetle Borer (C. S. No. 1891, 1923 and 2043).

(Plate XXV, fig. 1).

Foodplants—*China* (*Panicum miliaceum*).
Rice (*Oryza sativa*).

Grubs of this beetle have been observed from about April to August to bore into the stems of paddy seedlings and young *China* plants from the side near about the ground level. After gaining access into the stem they bore up and down the centre to some extent, filling the tunnel with pellets of excreta and causing "dead heart" characteristic of all internal borers. The full-grown grubs leave the stems and pupate underground, emerging as adults after six to seven days. It is not known where eggs are laid but from the habits of the larva it appears that they are deposited somewhere near or on the surface of the ground. The periods of egg and larval stages are also unknown. From observations however it seems that the lifecycle is completed in about three weeks. The adult beetles nibble the tissue from the surfaces of leaves as all flea beetles are ordinarily observed to do.

The grubs are observed to occur in large numbers in July and August and rank as a pest. They however occur in highland loamy soils and will be observed to infest millets and varieties of paddy which can be grown in such dry lands.

The full-grown grub (which resembles the young grub in appearance) is about 4 mm. long and about 0·75 mm. across the body which is semicylindrical in shape being slightly compressed in the dorsoventral plane. The head, the prothoracic and anal plates and the three pairs of thoracic legs are dark grey or almost black in colour and their surfaces somewhat glossy. The prothoracic plate is divided by a faint longitudinal line which is visible under lens. The general colour of the body is pale yellow which deepens to some extent before pupation. The hairs on the body are small and they arise from small somewhat glossy grey

patches which make the grub look spotted. The tubular anal process on the underside of the anal segment is made use of in locomotion. The spiracles can be hardly distinguished but a white tracheal tube is visible faintly under the skin running along the spiracles. The pupa is white, about 2·5 mm. long and roughly broadly oval in shape with the lobes of legs, antennæ and wings free. The beetles are black.

Chrysomelid beetle (C. S. 1640).

(Plate XXIV, fig. 2).

The larvæ of this beetle were collected in large numbers from sugarcane fields at Pusa in July, August and September. The pupal stage at this time was observed to be about five days.

Aphodius (C. S. 959, 1290, 1350, 1327).

Grubs were collected among *mootha* roots at Pusa in May and June 1915 which hibernated and attained adult stage in February 1916. Larva collected from harvested field on 29th February 1916, pupated on 2nd March and attained adult stage on 8th March.

From pupæ collected from cane field on 6th September, beetles emerged on 10th September and again from pupæ collected on 17th September, beetles emerged on 25th September.

For details of life-history of the other beetles and weevils mentioned in the paper " An Annotated List of Indian crop-pests " by T. Bainbrigge Fletcher, in the *Proc. of the Third Entl. Meeting,* may also be referred to.

Damage to rice.

As mentioned in the first paper the damage by borers to rice in the neighbourhood of Pusa does not ordinarily exceed about 4 per cent. Examination of stubbles at Chinsurah, Midnapur and Bankura in Bengal and at Cuttack in Bihar and Orissa did not show a higher percentage of damage.

I have taken up the question of rice stem borers in Burma and will be in a position to give very definite results at the next Meeting. It would be well if the work were taken up in all the rice-growing Provinces. Then we want to know the borers which can be actually held responsible for the damage. Detailed descriptions of the borers working at Pusa are given in the first paper.

The small amount of work done at the few places in Bengal mentioned above proved *Schœnobius bipunctifer* and *Chilo simplex* to be the principal agents.

In Burma, as I have already said, I have not yet come across *Chilo simplex.* There the principal borer seems to be *Schœnobius bipunctifer.*

Damage to sugarcane.

A good deal has been said in this respect in the first paper. The work was continued on the same lines after that paper was written and also a visit was paid to several places in Bengal, the cane-breeding station at Coimbatore, to Hebbal Farm in Mysore, to Manjri Farm in Bombay and to Nagpur to get a general idea of borer pests in these places. The occurrence of the beetle pests in the Kamrup Farm also gave an opportunity of gauging the external agents of damage, especially the Dynastine beetles, at their real capability of damage. The results of the further experimental work at Pusa and observations at the places mentioned are summarized below :—

The incidence of attack on sugarcane by the insects dealt with in these papers is correlated with climatic conditions. Favourable climatic conditions, enabling the crop to grow rapidly, have a great effect in controlling the activities of the pests, the crop in such cases easily outgrowing their attack. But with unfavourable climatic conditions, especially drought and want of moisture in the soil (especially in places like Pusa and many places in Upper India where no irrigation is given to the crop) the insects get the upper hand, and owing to want of growth and tillering on the part of the plants, the loss caused by their attack is not compensated for, the result being that the percentage of attack becomes very high.

At Pusa the principal damage to sugarcane is caused in the early stages of its growth in April, May and June when the climatic conditions are characterized by high temperature, low humidity (see the chart given in the first paper opposite page 370) and absence or scantiness of rainfall. In April 1920 the damage to some of the thick canes at Pusa was as high as 10 per cent. whilst at Coimbatore and Hebbal in Mysore, similar canes exhibited hardly any damage. The canes at these places, although planted about the same time as these at Pusa, were far more advanced in growth than those at Pusa on account of the more favourable climatic conditions prevailing at these places. The canes at Manjri, planted earlier and grown under irrigation were certainly not as good as the Coimbatore and Hebbal canes as regards growth and infestation by borers. This again is ascribable to the more unfavourable climatic conditions at Manjri than at Coimbatore and Hebbal.

The correlation of damage and climatic conditions holds good in all varieties of cane, thick as well as thin, but thin ones show a greater

immunity and also a greater resistance to drought. This will be apparent from a reference to the figures published in the Imperial Entomologist's Annual Report for 1920, pp. 73-74. We find therefore that particular varieties are suited to particular areas according to differences in local climatic conditions. As a rule thick ones do not fare so well in Upper and Western India as thin ones. Different varieties of cane show different degrees of pest resisting qualities though no variety has yet been found to resist pests wholly.

The presence or absence of alternative foodplants in the locality is observed to exercise a great influence on the occurrence of at least some of the borers in sugarcane. The remarks in this respect on *Diatræa venosata, Scirpophaga xanthogastrella* and the Noctuid borer C. S. 1666 may be seen.

The attempts at dealing with the borer pests of sugarcane and external agents of damage which work with effects similar to those produced by the borers must take into consideration the following points :—

(1) The suitability or otherwise of the cane itself to the climatic conditions of the place where it is grown.

(2) The habits of the cane, especially its capacity for tillering during the early stages of its growth, as varieties which tiller well show much greater immunity than those in which tillering is poor.

(3) The drought-resisting quality of the cane, especially in places where no irrigation is practised.

(4) The natural immunity of the cane against pests and diseases and (5) the effect of the presence or absence of alternative foodplants of the different borers.

The borer problem is not so acute at Coimbatore and other places in Southern India with favourable climatic conditions as in Northern India where in many places, such as Pusa, thick canes yield about 50 per cent. less than they are capable of yielding. As described in the first paper, only one out of every four shoots which grow of such canes comes to be harvested, the other three being killed. Therefore the problem for such areas seems to be to evolve a variety of sugarcane which can be planted at the time of the breaking of the monsoon or even after, but which will ripen at the time when canes do now-a-days. This can probably be done by selection of the tillers which grow late but ripen along with the mother canes.

If this be possible the borer question can be solved to a very great extent for localities with adverse climatic conditions such as Upper India.

15.—NOTE ON SUGARCANE BORERS IN THE CENTRAL PROVINCES.

By J. L. KHARE, B.A., F.E.S., *Lecturer in Entomology at the Nagpur Agricultural College.*

This preliminary note has been drawn up principally with an idea of collating the results of some experiments on sugarcane borers, which have been conducted at the different experimental stations in this Province. The experimental part of the work was carried by the late Entomological Assistant, Mr. Ratiram Khamparia, who was in charge of field work and thus had opportunities of visiting different farms to carry on the experiments. The writer of this note undertook the survey of different species of borers. Attached as he is to the College, it was not possible for him to go out personally to collect specimens and to determine the percentage of loss. He has, however, collected information and samples from the Superintendents and the Agricultural Assistant stationed in the cane-growing tracts. The tables of the distribution of the species of borers and the approximate damage caused by them are given at the end of this note.

Before giving a brief *resume* of the past work on borers, it is desirable to examine the position of the Central Provinces as a whole and in relation to the rest of British India with regard to the extent of cane cultivation. According to the latest agricultural statistics available, the area under sugarcane in this Province was 24,798 acres in 1917-18, thus being only 0·28 per cent. of the total area in the whole of British India, which was 2,808,204 acres. In the Central Provinces sugarcane cultivation is carried on practically in all the districts, the largest area being in the Bilaspur district and the least in Nimar. The distributon of the area can be well seen from the statement given below :—

District.	Area in 1917-18.	District.	Area in 1917-18.
Bilaspur	5047	Seoni . .	547
Bœtul	3434	Saugor . .	661
Raipur	2933	Damoh . .	440
Chhindwara	2496	Drug . .	361
Chanda	2146	Mandla . .	311
Balaghat	1537	Nagpur .	280
Bhandara	1502	Hoshangabad .	190
Jubbulpore	1486	Wardha . .	156
Narsinghpore . . .	1038	Nimar . .	116

The total area of 24, 798 acres is much less than what it was about fifty years ago. The causes, that have led to the continual decrease in area which has been steadily going on, are largely economic. Increase in the cost of cultivation brought about by high cost of manure and irrigation, foreign competition, etc., had a harmful effect on the area under cane and consequently the two crops of wheat and cotton have to a large extent replaced sugarcane, the former being in the opinion of the *raiyats* less expensive to cultivate and yielding a more certain return. It is not unusual to see in some districts disused wells adjoining cotton fields and showing where sugarcane was once growing.

Improvements in this crop are now-a-days effected in many ways, such as (1) extension of irrigation facilities, (ii) manuring and better methods of cultivation, and (iii) introduction of foreign varieties; this last factor is concerned with the subject matter of this note.

The foreign cane varieties of a better productive character which have been introduced, not only demand more care in cultivation, but, being mostly thick and high yielding, are more susceptible to attack of diseases, pests and animals than the harder and low yielding local thin canes. A study therefore of these enemies is more necessary, and it is in respect to the second, *i.e.*, insect pests, that experiments have been carried out on several farms to study the relation of the introduced varieties of canes to stem-borer attack.

Quite a large number of foreign and local varieties were tried to find out suitable canes for gur-making, and it has become obvious that the thin and hard canes are less damaged by borer than the soft canes and that early planting gives greater immunity to borer attack than late planting. These inferences may have been drawn by the cultivators from their accumulated experience of years, but actual experiments conducted with those objects in view are more instructive and base the results on scientific *data*.

In 1913-14 at the Tharsa Experimental Station an experiment was started to ascertain the immunity of different varieties to stem-borer, The observations are tabulated below :—

Variety.	Total number of canes attacked and uprooted per acre.	Number of canes per acre.	Percentage of attacked canes to the total number.
Khari	493	82,000	0·5
Sannabille	487	74,640	0·6
Lanji	997	52,160	1·9
Red Mauritius	767	37,360	2·4
Pundia	290	23,000	1·2
Ashy Mauritius	219	30,600	0·6

In the following two years at the same station the examination of immunity was continued and it was found out that the superiority of *Khari* and *Sannabille* in tillering, placed them at an advantage over other varieties, though the difference in the degree of affection was not very marked. Again during the years 1912-13 and 1913-14 at Telinkheri station an experiment was started to find out the percentage of cane affected by stem-borer, and the average number of canes per stool, which again showed that *Khari* and *Sannabille* are superior to the rest.

Variety.	1912-13.		1913-14.	
	Per cent. of attacked canes.	No. of canes per stool.	Percentage of attacked canes.	No. of canes per stool.
Khari	...	15	...	20
Sannabille	...	10	...	15
Lanji	17·6	8·5	10	6
Red Mauritius . . .	20·4	9·0	15	5·0
Pundia	...	4·2	9	3·0
Ashy Mauritius . . .	8·0	7·5	12	6·0

Although the percentages of attacked canes in the first two cases are not recorded, yet the experience is that these thin varieties are less susceptible to stem-borer.

The time of the planting of canes is another factor which plays an important part in altering the extent of attack by stem-borer. Both thin and thick varieties of canes were studied in respect of this. The results of the experiments would appear to indicate that cane planted in October gives a much larger yield than that planted in February and March. When planted in October, it gets a good start before the hot weather sets in and the moths of the borers regain their normal activity after a spell of cold weather. Borer does all its damage between February and June, but it does not attack cane appreciably when it is four to five feet high in February. As by early planting the damage appears to be reduced, the gain will be very great.

The result of planting at different dates is tabulated below both for thick and thin canes.

THICK CANE.		THIN CANE.	
Time of planting.	Number of canes per acre.	Time of planting.	Number of canes per acre.
1st October	38,800	25th December	64,200
1st November	27,000	25th January	59,640
1st December	30,040	25th February	42,040
1st January	28,080	25th March	37,000
1st February	26,080	... ...	...
1st March	12,560	... ...	...

The general belief which has long gained ground in the minds of cultivators that borers do considerable damage to thick canes during the hot weather is thus supported by the results of the experiments.

The experiments conducted in the past years were devised simply to ascertain the damage caused by borer without paying any special attention to find out the species of borers. Moth borer (*Chilo simplex*) was considered to be the chief borer and references to it are often found in several inquiries and reports of cane cultivation . Later on the specimens, determined as *Chilo*, were overhauled and were found to have comprised other genera and species associated with *Chilo simplex*. In the Central Provinces till very recently three species of borers were known, *viz.*, *Chilo simplex*, a species of *Sesamia* and *Scirpophaga xanthogastrella* (*auriflua*). But, consequent on the more definite determination of the species of borers, it was found necessary to conduct a survey of cane-borers in order to ascertain the species involved, their probable distribution in different cane-growing tracts and their liking for any particular varieties of canes if there be any. With the above object in view an inquiry was conducted in the years 1919-20. During the inquiry the following varieties of canes were seen largely growing both at the experimental and the demonstration station :—

> Red Mauritius, Ashy Mauritius, Striped Mauritius, *Pachrang*, *Khari*, Java 247, *Sannabille*, *Dhawari* (thick cane) *Bungle* (Thin white cane) *Pounda*, *Yuba*, *Pundia*.

I gathered information regarding the time of planting sugarcane, percentage of damage caused by borers and varieties of canes planted from about forty different places in this Province. The time of planting ranges from November till March and percentage of affectation by borer

varies from 1 and even less to as high as 50 to 75 ; the latter was often noticeable specially in thick canes.

From the specimens of borers reared I found that there are five different species, *viz.*, *Diatræa auricilia*, *Emmalocera* (*Papua*) *depressella*, *Scirpophaga xanthogastrella* (*auriflua*), *Sesamia uniformis* and *Sesamia inferens*, while *Chilo simplex*, the long-known moth-borer of sugarcane, was not found occurring at all. These different species of borers were found attacking any variety of cane and therefore I could not fix upon any particular variety of cane as being a favourite food of any particular species of borer. I have pointed out above that I got samples from forty different places ; these however do not represent the sugarcane growing tract to a very wide extent, but can be considered to be a fairly representative collection. In the table below I have shown the distribution of the species of borers and in the next following damage, time of planting and variety of cane.

I may here remark that the work on cane-borers done during the past years has not been very systematic and entirely satisfactory, but this is all that could be done by the very inadequately staffed section in this Province. The problem of cane-borer is worth tackling on more systematic lines, particularly as the Agricultural Department is trying to spread cane cultivation.

Locality.	*Diatræa auricilia*	*Emmalocera* (*Papua*) *depressella.*	*Scirpophaga xanthogastrella.*	*Sesamia inferens.*	*Sesamia uniformis.*
Nagpur . .	O	X	X	O	O
Tharsa . .	O	X	X	X	O
Sindewahi .	O	O	O	X	X
Raipur . .	O	X	X	X	O
Bilaspur . .	O	X	X	X	O
Betul . .	O	X	X	X	X
Jubbulpore .	O	O	O	O	O
Waraseoni .	O	X	X	X	X
Drug . .	O	X	X	O	X
Hoshangabad .	X	X	X	O	X
Chandkhuri .	O	O	X	X	X

O shows presence, and X shows absence.

Statement showing locality, variety of cane, time of planting and probable damage by borer.

District.	Locality.	Variety of cane.	Time of planting.	Percentage loss by borer.
Bilaspur	Bilaspur	Java 247	January	1
		Khari	"	1
		Sannabille	"	1
Raipur	Kurud	*Dhawri*	February	10
		Ashy Mauritius	Middle of February	5
		Striped Mauritius	....	5
	Ninwa	Java 247	January	2 to 3
		Khari	....	..
	Baronda	Java 247	First week of February.	1
		Khari	....	..
	Nakpura	*Bungle*	End of January	25
	Chandkuri	*Khari*	Middle of January	20 ratoon crop
	Jugesar	Red Mauritius	Last week of January	40
	Tor	Ashy Mauritius	February	70
Nagpur	Nagpur	*Ponuda*	January	5
Bhandara	Tharsa	*Khari*	February	5
		Sannabille	"	5
	Banor	*Khari*	November	1
Chanda	Sindewahi	*Khari*	November	1 to 2
	Amehi	*Dhawri*	Middle of February	10
	Matang	Thick cane	1st week of March	50
	Chicha	"	" "	25
	Pendhri	"	" "	25
	Tarra	"	" "	25
Jubbulpore	Bichhai	Red Mauritius	January	10
		Pounda	"	10
		Pachrang	"	10
	Adhartal	*Khari*, *Poundia* and Red Mauritius.	January to March	2
	Bilaspura	*Khari*	Middle of February	5
	Mahaajpur	*Pounda*, *Yuba* and Red Mauritius.	January	5 to 10
	Kauahanpur	*Pounda*	January	10
Balaghat	Waraseoni	Java 247	Middle of January	10
		Khari		
Hoshangabad	Powerkhera	Red Mauritius	January	4
Betul	Betul	*Augrezi*, *Pachrang* Red and Ashy Mauritius	February	8 to 10
	Betul Farm	*Augrizi*, Red and Striped Mauritius	End of December	3 to 5.

16.—*JUAR* STEM-BORERS (*CHILO SIMPLEX* AND *SESAMIA INFERENS*).

By T. N. JHAVERI, L.AG., *Entomological Assistant, Bombay.*

These are the species which are principally responsible for so much deterioration of the monsoon crop of *Sorghum* in the Surat district. Of the two species, *Chilo* is mainly responsible for attacking the crop in its seedling stage, on account of which the cultivators are required at times to resow their crops once or twice. In a normal year their depredations are not so severe. At that time if proper investigations are being made, on^ will notice a large number of "Tachinid" fly parasites playing a ve: important part in controlling this pest; but in the subsequent year of famine, it has been chiefly found that this borer-attack in the crop is very severe and the percentage of parasites is very low in the beginning. That is, in the first two months of the crop, in July and August and at times in September, the attack of this borer is very severe, but later on in September the parasites begin to outnumber the pest to such an extent that about the beginning of November this *Chilo* appears to have been totally annihilated and hardly any caterpillars of the same are being found in the stalk. While this is going on, the other kind of borer, namely *Sesamia*, begins to gain ground. It is rather slight in September but in October-November, it greatly increases and rests in the caterpillar stage in the months of December and January, depending upon the severity of winter. This second borer is not preyed upon and controlled by fly parasites and in winter this fly parasite does not breed. In summer, this second borer breeds in sprouted shoots coming out from the sides of *juar* stumps remaining in the ground.

Taking the above points of their lifehistory and habitat into consideration, the following measures were tried for these pests :—

1. The first measure that was being adopted in controlling the caterpillars of *Chilo* was the removal of affected plants of *juar* with dead-hearts at the first and second thinnings of the crop. It is generally the practice in that part to make the sowing thick in the beginning. When the crop has grown about a foot to a foot-and-a-half tall, the first thinning is given, which comes after a period of about three to four weeks from the date of sowing and the second thinning is made two

to three weeks later. At these two occasions if all affected plants with dead-hearts are uprooted and burnt and wherever it is found that in doing so the rows become very gappy then, the shoots with dead-heart are cut back to the ground level and allowing the side shoots to grow up, the pest is very easily controlled at a very low extra cost and its further spread is too much checked. During the last monsoon this was being practised at Surat Government Farm. At that time the percentage of attack varied from 1 per cent. to 14 per cent. in the crop and no further treatment was given to the crop thereafter for this kind of borer. In the year 1913, about 17 acres of *juar* were similarly treated and the cost of such a treatment came to about 0-3-9 per acre. In the year 1912, the attack of *Chilo* borers was very severe and the removal of affected plants with dead-hearts was not rigidly followed in the beginning. So the pest ranged from 20 per cent. to 60 per cent. in some plots, on account of which several plots were grubbed up and resown. A plot of three acres in which the plants were attacked to an extent of 60 per cent. was given the following treatment :

All affected shoots with dead-hearts were cut back to the ground level. In spite of that the caterpillars in a good many cases were found in the portion of the stump remaining in the ground which were also being picked and killed by means of a needle or thorn. The cost of such a treatment came to about Rs. 1-2-0 per acre. Later on the treated crop gave out very vigorous healthy shoots and in comparison with the resown and untreated plots, it yielded more in seed, kadbi and chaff, which will be seen from the figures given below :—

Plot No.	Crop.	Yield per acre in lbs.		
		Grain.	Kadbi.	Chaff.
336	Perio Juar	500½	1,004½	194½
337	Chafli Juar	315¾	502½	112
338	Sholapuri Juar	688	1,184	218

From this it leads us to conclude that though timely treatment of the removal of affected plants at the time of thinning was not practised, however, it yielded more in comparison with other resown and untreated plots by cutting back the affected shoots with dead-hearts later on.

2. Tachinid fly parasites also play a very important part in controlling this borer. In the beginning of the monsoon these flies are

hardly found but later on they multiply and in October and November they increase to such an extent that this borer is totally annihilated and hardly any *Chilo* caterpillars are found in the stem. In the year 1919, owing to late rains, the sowing of the crop was delayed so the percentage of borer attack in the crop about the middle of August varied from ·25 per cent. to 1 per cent. which increased up to 47 per cent in some plots about the middle of September. At that time the Tachinid fly parasites were not sitting silent. They were also trying their utmost to beat the borer down and on calculating the percentage of the parasites to that of borers, it was found to be about 10 per cent. at that time, which increased up to 70 per cent. in the middle of October, which was calculated by actually splitting open the affected stems and taking the proportion of borers to that of the parasites. In this way, in the later stages of the crop this borer is very effectively checked by these parasites. Trials were made to rear and breed out these fly parasites on a large scale in the insectary, and for that proper arrangements were made to feed the adult flies artificially on sugary juice ; but I have not yet succeeded to make them lay eggs on their hosts in a rearing cage, for which further trials are in progress. Another difficulty about the breeding of these flies is that they cannot be reared and bred out in winter in the insectary as well as in the field.

Regarding the other borer, *Sesamia*, the caterpillars of which begin to appear in the more advanced stage of the crop, it does not kill the plant outright like the first, though several of them are found in one stalk ; however, it helps to decrease the yield of grain in ear-heads by making them small and bunchy at times. It usually begins from September and breeds on till the crop is being harvested, then it goes in the offshoots given out from stumps remaining in the ground where it breeds even in summer. During the severe cold of winter it hibernates in the caterpillar stage in stalks. For tackling them nothing could be done till the crop is being harvested, then the remaining stalks and stumps in the ground could be dug out and burnt or split up and chaffed.

There is one Braconid parasite which preys upon these caterpillars, but it is not so prolific and efficient as the Tachinid ; so the best way of controlling this borer is by the immediate removal of stumps remaining in the ground after the harvest and burning them to put a stop to the further breeding of the pest. Further, on examining the harvested stalks of *Sorghum*, it was observed that in the last month these stalks were found to contain the *Sesamia* borer, attack varying from 7 per cent. to 30 per cent.

If therefore these stalks which are dried and being stored as fodder for cattle in summer and the following monsoon and which contain so much percentage of borers in the hibernating state at present are chaffed by power or hand-machines, there is every probability of destroying most of these borers.

Many of the names of these borers are still very uncertain. We can discriminate the larvæ and the pupæ fairly easily, but the determination and nomenclature of the adults cannot be taken up until we get definitely named material. I was hoping to get this done when I attended the Entomological Conference in London, to which, as you know, I was prevented from going. About six years ago we sent material to Sir George Hampson for determination but his descriptions are difficult to apply to particular forms in many cases.

The subject of cane-borers is a very important one. The Sugar Committee was brought into existence through the very great shortage and consequent high price of sugar. The total damage done by borers to sugarcane is enormous. In the evidence which I gave before the Committee at Simla I estimated it at Rs. 300,000,000. When our staff is extended I hope to place at least one expert entirely on this work.

Mr. Ghosh in his paper mentioned that *Diatræa* attacked the canes in early stages of its growth only, but in Mysore I have found larvæ of *Diatræa* attacking mature tops at the time of harvesting.

It would be useful if you would send in specimens to Pusa for examination, as very little is known at present regarding cane-borers in Southern India.

Are any kinds of cane immune ?

No ; but thin varieties of cane are less attacked than the thick ones.

Regarding the percentage of attack in paddy, experiments are proceeding to determine this, for I think it is usually much exaggerated. I was told by a Farm Manager of a 60 per cent. attack of *Schœnobius bipunctifer* ; an actual count over a hundred acres showed 4 to 5 per cent. At Coimbatore on paddy in the Farm, I asked the Manager to estimate the damage by borers and he placed it at 25 per cent. ; on a count over half-an-acre, this proved to be 0·4 to 0·7 per cent.

Scolytids are potential pests of cane. I have found one attacking *cumbu*. It has not been recorded before.

In Konkan I noticed in each plot of a 20-acre field damage of more than 70 per cent. due to *Schœnobius*.

I should like to know if the damage by *Pachydiplosis oryzæ* occurs year after year ?

No ; we get it once every third or fourth year.

It would be of very great practical interest to know the causes of such fluctuation in the amount of damage done ; information on this subject might throw a good deal of light on the question of control. Possibly it is due to relative abundance of parasites.

As to Cecidomyiads, there is one plot which I have observed to be badly attacked year after year.

We are starting a special sub-station at Samalkota to study Rice problems.

17.—PRELIMINARY NOTE ON WINTER SPRAYING AGAINST MANGO HOPPER (*IDIOCERUS SPP.*), VERNACULAR NAME *TELA*.

By M. Afzal Husain, M.A. (Cantab.), *Government Entomologist, Punjab, and* Hem Singh Pruthi, M.Sc., *Assistant Professor of Entomology, Punjab.*

Idiocerus, the notorious and serious pest of mango inflorescence, occurs everywhere in the mango-growing tracts of the Punjab. It is especially abundant in the districts of Hoshiarpur, Gurdaspur and Lahore. The species that are commonly met with in the Punjab are *I. atkinsoni* (*British India Fauna, Rhynchota*, Vol. IV, p. 186) and another smaller species that most resembles *I. clypealis*. The identification of *I. atkinsoni* was very kindly verified by the Director, Imperial Bureau of Entomology, London.

Amount of damage. The amount of damage that this pest causes to the Province can be estimated from the fact that a garden near Shalamar, Lahore, which used to bring to its owner some Rs. 6,000 per annum, has, since 1912, when *Tela* began its ravages, steadily gone down in its productivity, year after year, and during the last three or four years it has not produced even a hundred ripe fruits, and this in spite of the fact that it has been flowering profusely every year. This garden covers only 13 acres of land, and the loss incurred annually is about Rs. 6,000. In Gurdaspur district, a mango garden may sometimes extend over eight miles, and on the whole, nearly half of the cultivated land is under this fruit. In the Hoshiarpur district alone, there are over 14,932 acres of land under mango-orchards, and this fruit is the principal source of income of the people. About this district, Montgomery, in his Settlement Report (1883) says :—" when mango fruit fails, there is loss to the district of two lacs of rupees." In Lahore district also there are many big mango gardens which suffer every year from the attack of *Tela*. It is thus not difficult to realize that this pest is causing an immense loss to the Province.

Nature of damage. Hoppers that survive the preceding winter, move out in the beginning of the spring, from under the bark, and cluster on the floral buds, where they remain sucking the sap during the growth of the inflorescence. The female starts laying eggs when the blossom heads appear, *i.e.*, about the second or third week of February. The nymphs are met with, for the first time, in the beginning of March. They

moult five times during their life and reach the adult stage in about 18-20 days. Most probably there is only a single generation in a year and the hoppers spend eleven months of their life as adults and it is as such that they hibernate.

It is in the nymphal stage that the hoppers are most injurious to the flowers. The nymphs, which are in enormous numbers, are found clustering on the inflorescence. They suck the sap with the result that the flowers shrivel, turn brown and ultimately fall off. The attacked inflorescence has a blighted look and in case of severe attacks, can be noticed as such from a great distance. It seems likely that "Honey dew," falling from the higher flowers on the blossoms below, does some damage to the flowers and probably renders pollination difficult.

The old gardens fall a special victim to this pest and the attack is all the more severe when the trees are very closely grown. Trees near the borders are generally less infested than those situated in the interior. In short, old dark and dense gardens, in regions having a hot and a slightly moist climate, afford a good breeding place for the hoppers.

Habits. Soon after attaining maturity, the hoppers leave the blossoms and move to the trunks. During the summer they congregate in large numbers on the lower surfaces of the basal horizontal branches of the trees and are found mainly in this portion between 9 A.M. and 5 P.M. Only a few of them remain on the leaves during this time of the day. But in the mornings and evenings the case is reversed; they are more on the underside of the leaves than elsewhere. In this season, even during the earliest hours of the day, the hoppers are very active and the mere bringing of the hand near them, however gently, will make them hop off.

In winter they are very inert and expose themselves very little to the external cool air. They hide under the bark, lie concealed in the crevices of the stems or find shelter between such leaves as are webbed together by spiders. Winter seems to effect them adversely, as at the end of this season their number is greatly reduced.

Control. It is clear, from what has been described previously, that the breeding season of the hoppers does not precede or follow, but coincides with the flowering season of the mango trees. An attempt to spray the plants in the spring when the pest in its nymphal stage, is likely to do more harm than good, because there is every chance of killing the flowers along with the insects. The opened mango flowers are so delicate that they cannot stand a forcible spray even of warm water. With this in view we tried winter sprays, but we found that after 10 A.M. the hoppers were too active to receive a sufficient shower of insecticide to kill them. It was, therefore, thought advisable to hit them when

they were more sluggish. On visiting a garden early in the morning at 6 A.M., in the middle of December, when the weather is sufficiently cold in the Punjab, the hoppers were found quite inactive, hiding behind the bark and reluctant to hop off even when disturbed with the end of a pencil. Spraying operations were at once commenced and some 400 trees were taken in hand for experiment. The trees were sprayed for only about three hours every day (6 A.M. to 9-30 A.M.).

Various insecticides, such as Resin wash, Fishoil Resin soap, Macdougal's fluid, Sanitary fluid, Soap, Crude oil emulsion, Tobacco decoction, and Phenol were tried one after the other, and it was found that an insecticide having Resin or some other sticky substance as one of its constituents was more effective, because it made the sluggish hoppers stick to the plants.

Resin wash was tried (3 seers in 30 gallons of water). Plants were visited five hours after the spray, and insects were found stuck to the tree trunks, some dead, but many still kicking and moving their legs. This showed that Resin by itself did not kill them. It was therefore proposed to mix a strong contact poison with resin and the following were tried :—

Sanitary fluid, Tobacco decoction, Crude oil emulsion, Solignum, and Soap. As is evident from the examination of detailed observations given below, Resin and Solignum or Resin and Crude oil emulsion, proved very effective; the former being cheaper was given preference. It must be remarked that pure Resin is not so sticky as crude Resin, hence the latter was used. To dissolve Resin in water, the addition of a small amount of crude oil was essential.

The following are proportions of the different constituents of the insecticides used :—

Resin 2 seers Soda 1 seer Solignum 2 seers Water 25 gallons	or	Resin 2 seers Soda 1 seer Crude oil ½ seer Solignum 2 seers Water 25 gallons	or	2 seers of Crude Oil Emulsion.

The trees under experiment were 60 years old, and in height varied between 25-30 feet. On an average ten gallons of insecticide were required for one tree. The cost of the insecticide was 0-6-0 for Resin and Solignum and a little more for Resin and Crude Oil.

The garden under experiment is notorious for being the most heavily attacked mango-orchard near Lahore. It is to bear fruits next summer, but the effect of the winter spraying was evident from the number of dead hoppers that were seen a short time after a spraying operation. To get an idea of the numbers killed, counts were made and the hoppers seen within a definite period of time, dead or living, were recorded. The results of these counts are given below :—

Date.	Insecticides.	Period during which hoppers were counted.	Number of dead hoppers seen.	Number of living hoppers seen.	Percentage of dead hoppers.	Remarks.
13th January 1921	Resin and Crude oil emulsion.	25 minutes	200	19	92	
	Ditto	Ditto	32	11	75	
17th January 1921	Ditto	Ditto	12	8	60	
	Ditto	Ditto	16	11	60	
	Ditto	Ditto	32	13	70	Trees very small.
	Ditto	Ditto	33	14	70	
	Ditto	Ditto	61	11	75	
	Ditto	Ditto	24	9	72	
	Ditto	Ditto	40	19	66	
14th January 1921	Resin and Solignum	30 minutes	404	61	87	Many of the dead hoppers were washed down on the ground so the percentage of the dead insects should be higher than the one shown here.
	Ditto	Ditto	260	19	93	
	Ditto	Ditto	257	65	75	
	Ditto	Ditto	147	34	78	
	Ditto	Ditto	63	50	48	
	Ditto	Ditto	297	30	92	
15th January 1921	Ditto	Ditto	38	36	50	
	Ditto	Ditto	43	21	67	
	Ditto	Ditto	36	17	71	
	Ditto	Ditto	65	61	56	
	Ditto	Ditto	198	95	73	
	Ditto	Ditto	59	32	66	
	Ditto	Ditto	92	9	88	Ditto.
21st December 1920	Resin and Crude oil	2 hours	245	25	89	
	Ditto	Ditto	166	30	85	
21st December 1920	Resin and Sanitary fluid	25 minutes	140	40	71	
	Ditto	Ditto	118	24	75	
	Ditto	Ditto	92	12	89	

Conclusion. We have been able to give only one thorough spray to the trees this year. There were many difficulties as regards supply of water, a thing mostly needed for our operations. The owner of the garden was absolutely indifferent. The trees were very tall and the spraying machine at our disposal was the ordinary Four-oaks lime washing machine. With a power sprayer that is expected soon, we hope to achieve better results.

As is shown in the accompanying table, we killed 56-92 per cent. of the hoppers, in one spraying, but a number escaped. We are, however, inclined to believe that two thorough sprayings must be given in order to exterminate the pest totally. The first in the beginning of December. The second in the middle of January ; if there is need a third might be given in the second week of February but not later. Spraying should be done during the mornings only, when the temperature is so low that the hoppers are inactive and do not fly much.

17th-18th January 1914. Laid 18 eggs. Male removed, transferred to Y.

18th-19th January 1914 laid 14 eggs. Transferred to Z. Morning of 20th found dead. Total *32* eggs.

Moths which emerged 19th January 1914, on 20th January 1914 were put into 4 cages. *17* eggs were laid including a chain of 9 attached to a dead moth. By 24th all moths were dead.

Cage 6. A pair put in 21st January 1914 and on 21st-22nd January 1914, 3 chains of eggs were laid with hairs adhering, 56 eggs in all. Moths were transferred to cage 7. By 23rd January 1914, 53 eggs were laid and male was dead. Female transferred and laid 48 eggs. Female transferred, laid 12 more. Female transferred, 2 more (26th January 1914), 28th January 1914, 2 more. 29th January 1914 moth found dead *i.e.*, between 21st January 1914 and 29th January 1914, laid *153*. Time taken to hatch :—

Eggs laid 15th-16th January 1914 hatched out by 8-30 A.M., on morning 21st January 1914, remainder of these had hatched by 22nd January 1914, *5-6 days*.

Eggs laid on night 16th-17th January 1914, some hatched 21st January 1914, others 22nd January 1914 ; *4 to 5 days.*

Eggs laid on night 17th-18th January 1914 hatched 23rd January 1914, *5 days.*

Cage X, eggs laid on night 17th-18th January 1914 hatched 23rd January 1914 am. *5 days.*

Cage 7, eggs laid on night 18th-19th January 1914, hatched 24th January 1914 am. *5 days.*

Short description of egg (Plate XXVI, Fig. 1) Egg has been already described as a flattened scale-like object, pale yellow in colour. On the 2nd day the yolk appears to be concentrated at the sides of the egg and a clear kidney-shaped space appears in the middle.

3rd day this space is larger, yolk is more concentracted, embryo is seen clearly.

4th day, red patch appears at the end of the embryo and the edges of the clear area are becoming opaque.

5th day. Two dark eye like spots appeared, behind these an oblique red brown patch ; the red patch has deepened and forms a semicircular band at one pole.

Larva, just hatched, rather less than 1 mm. in length. Colour yellow brown with two red brown stripes on dorsal surface of IV, V, VI, VII

segments. Larva is beset with spiniferous processes placed in four rows, 2 lateral, 2 subdorsal. The spines are bifid at the tip. The head is hidden by the projecting prothoracic shield and the anterior spines. It is strongly mandibulate and has singularly large legs. Prolegs absent and replaced by the foot typical of Limacodids. (Plate XXVI, Fig. 2).

Larval life. After first moult which takes place in 48 hours from the time of hatching the larva is 1·4 mm. in length. The colour bands have deepened and concentrated. Spiniferous tubercles are a quite different shape. Central spine is not bifid and there are two circles of strong dark spines surrounding base of central spine.

In another 48 hours larva moults again. It is now 2·2 mm. long. Colour is greener, dorso-lateral colour band deeper in colour and more concentrated.

Next moult (48 hours) length 3 mm. Dorsal spiniferous tubercles are white with black spines. First three lateral spines white, tubercles black, anal tubercles have black spines, others colourless.

When 5·5 mm. in length body is green above with dorsal stripe of anterior $\frac{1}{3}$ greenish bordered by pink and yellow streak, post. $\frac{2}{3}$ purplish bordered by yellow, this is constricted in two places by the yellow encroaching upon the purple dividing it into 3 parts. Tubercles have several rows of spines; terminal spines long and white (pale) 3 anterior tubercles darker.

Full-grown larva, 8-11 mm. in length.

General ground colour apple green. 3 anterior spiniferous processes rose colour or, and more usually, bright crimson.

Running fore and aft a pair of bright yellow streaks placed latero-dorsally along the bases of the latero-dorsal rows of processes placed between the two rows of latero-dorsal processes are three lozenge-shaped patches of bright crimson between segments I and III, V, VI, and on VII. Lozenges are separated by green, or by dilations of the yellow streaks. There is faint mid-dorsal narrow yellow streak. This is the average typical specimen.

In some the crimson patch occupies the greater part of the mid-dorsal area—the three lozenges forming one stripe and extending forward along the yellow streaks and enclosing a median green patch joining with the red of the anterior tubercles. In others again the two posterior lozenges coalesce, leaving the anterior one separate. Again, two red spots mark the position which should have been held by the lozenges, the remainder of the space being green. Finally, some show no trace of red lozenge-shaped patches; the larva is entirely green except for a pair of latero-dorsal yellow stripes.

The cocoon is spherical and kept in place between the leaflets by a tangle of silk threads.

The pupa is 6 mm. in length, stout and roughly oval. Eyes are prominent, wing rudiments plainly seen and extending to eighth abdominal segment. They are separated medianally by leg rudiments. Between eyes is a broadenad cross ridge of chitin. Posterior end is blunt and

The moth has already been described. It possesses the rather quaint habit of sitting up like a " begging dog."

One unfertilized moth lived in laboratory, 21st-25th January 1914; fertilized moths lived from 4 to 9 days. The average life appeared to be 5 days but this was under Insectary conditions and not the actual life in nature.

Characteristic lifehistory. Notes.

Eggs laid 7th-8th March 1914.

Hatched, 11th-12th March 1914. Spines bifid at tip; larvæ did not feed, had appearance to naked eye of transparent ovoid bodies with purplish nucleus (·8 mm.).

1st moult, 12th-13th March 1914. By 11 A.M., in most cases. Period 12-14 larvæ were feeding on the parenchyma and leaving veins (1·4 mm.).

2nd moult, 17th-18th March 1914. One moulted before others and was feeding on 18th morning.

20th both larvæ feeding on parenchyma by 11 A.M., on 21st both were about to moult (2·2 mm.).

3rd moult, 21st-22nd March 1914. Moulted and feeding by morning of 22nd March 1914; length 3·2 mm.

4th moult, 24th-25th March 1914.

24th March 1914, one was about to moult.

25th March 1914, other about to moult.

5th moult, 30th-31st March 1914. One larva died. Survivor was of the green variety with only very faint pink colouration.

8th April 1914. Found to have pupated.

20th-21st April 1914. Moth emerged.

Total length of life from egg to moth, 44 days.

Total life from egg to pupa, 31 days.

Other egg period very constant at 4 days.

Larval life, 31 days.

Pupal periods, 14 to 16 days.

This may be taken as typical, others showed as above. The larva is parasitized by an unnamed Braconid.

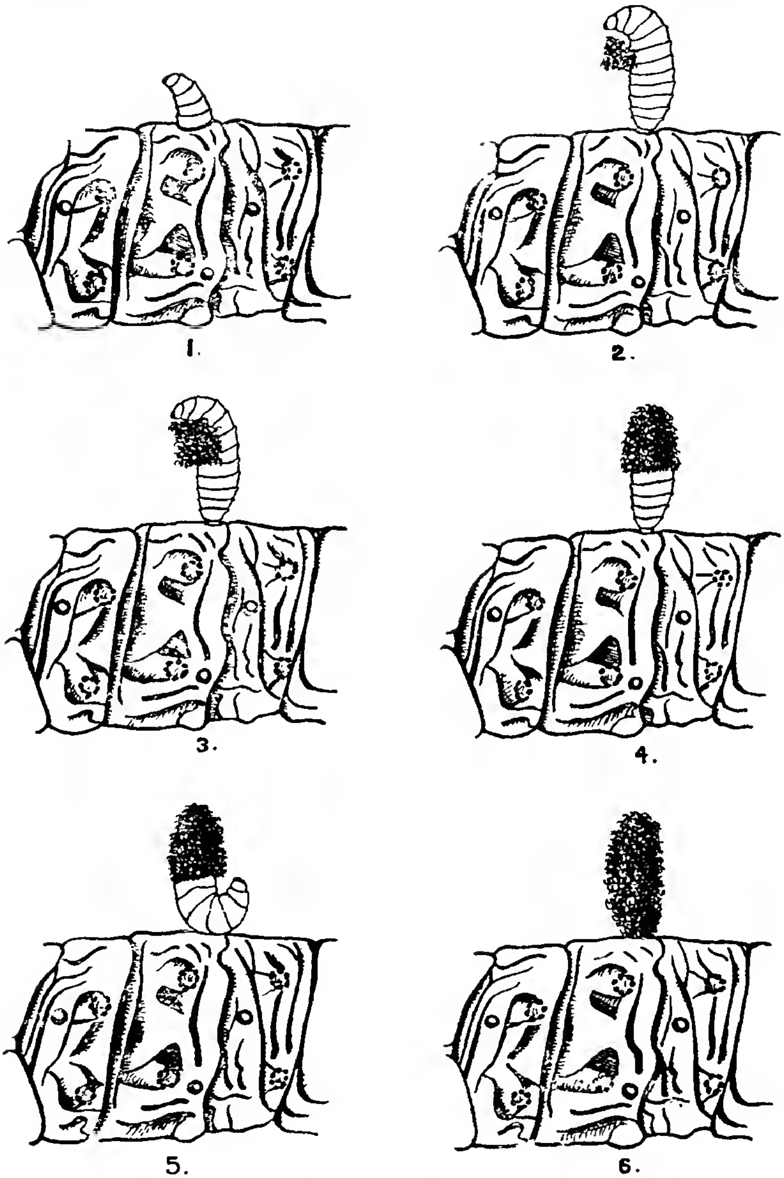


Fig. 1.—Process of spinning of cocoons by the larvæ ; 1, mature larva emerging through skin of host ; 2, larva commencing to spin its cocoon ; 3, spinning continued ; 4, upper half of cocoon finished ; 5, the larva turning around and finishing off the second half of the cocoon ; 6, cocoon completed.

Microplitis sp.

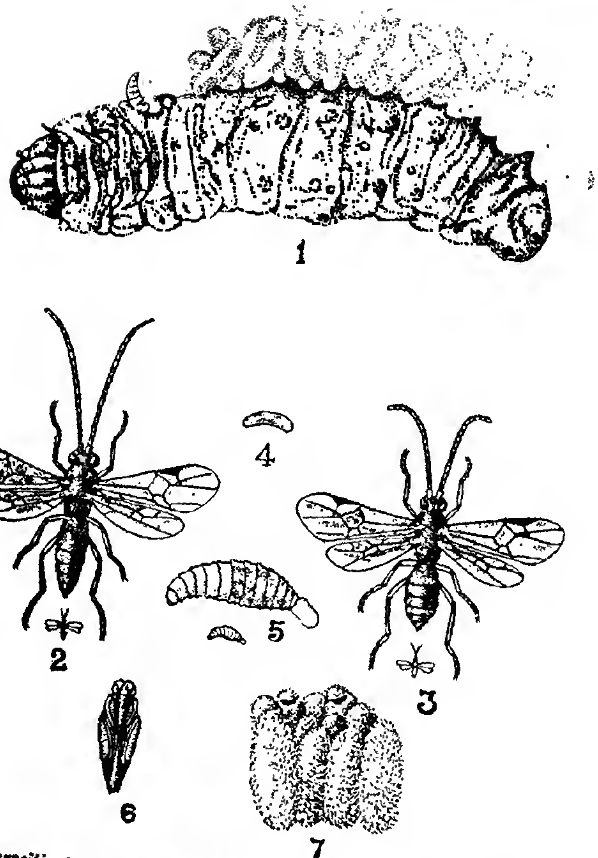


Fig. 2.—1, parasitic larvæ which have emerged and spun their cocoons on the body of the host caterpillar, which has died (×3); 2, adult parasite, male (×7); 3, adult parasite, female (×7); 4, egg, highly magnified; 5, larva, full-grown (×4); 6, pupa (×4); 7, cocoons (×4).

Microplitis sp.

19.—NOTE ON A BRACONID PARASITE OF *AGROTIS YPSILON*.

(Plates XXVII-XXVIII).

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Agrotis ypsilon, Rott., which is a very serious pest of the *Rabi* crops in some of the *chaur* lands in the Province of Bihar and Orissa, has several parasites, none of which under natural conditions can keep the pest under control, on account of the adverse conditions obtaining in the areas concerned. Of these, the most common is a Braconid, probably a *Microgaster* sp., which is much in evidence in the destructive second brood of the caterpillar pest, when it is too late to be of any real benefit to the crop, since by the time an affected brood of caterpillars succumbs to the attack of the parasite the damage to the crop has already been done. For the last two years a considerable amount of work has been done on this parasite, in the Insectary at Sabour, with a view to finding out if it is possible to utilise it as a means of control of the cater pillar pest. The parasite has not been identified yet but the Imperial Entomologist has kindly undertaken to get it named correctly. A short summary of the work is given below :—

I. *Life History of the parasite.*

Eggs. The eggs are cylindrical and elongated with the two ends round and slightly curved in the middle [Plate XXVII Fig. 2(4)]. They are extremely small, not visible without the help of a lens or microscope and are laid just under the skin of very young host caterpillars. The eggs are laid on any part of the host's body but generally on the dorsal side of the last segment of the thorax or first few segments of the abdomen. An adult female suddenly drops on the back of the host caterpillar and immediately commences to make the incision with the ovipositor. The host wriggles with pain and sometimes turns round and round but the parasite does not let go its hold. The number of eggs laid at a time by one female parasite has not been determined but under field conditions it is certain that one female lays eggs on more than one host. The egg content of a gravid female parasite has, on dissection, been found to be about 200 but the result of dissection of a large number of naturally parasitized caterpillars collected from the fields shows that the number of parasite larvæ in one host insect's body varies from 20 to 60. Under

Insectary conditions, however, when one caterpillar was confined with several pairs of parasites, it has been found that as many as 400-500 eggs may be laid on one host. But in cases like these the number of parasites is so disproportionately large that the caterpillars soon succumb to their attack and the grubs consequently die before coming to maturity. No such case has been recorded among naturally parasitized caterpillars where on account of their small number and consequence abundance of food supply they mature and come out to spin cocoons outside the body of the host. It has not been possible to determine the exact length of the egg stage as the eggs hatch inside the body of the host. It may be said here that egg laying is always done on very young host caterpillars during the first and second instars only.

Larva. A full grown larva is 5·5 mm. long and 1·5 mm. wide, thickest at the middle narrowing to a point at the anterior end and bluntly rounded at the posterior where beyond the last abdominal segment there is an elongated oval pouch-like appendage about 1 mm. long with a constriction in between it and the abdomen [Plate XXVII, Fig. 2 (5)]. There are fourteen segments in the body besides the pouch and the head is retractile. The colour of a young larva is milky white but as it grows the middle portion of the body becomes gradually darker until in the full grown stage it becomes very dark with the two sides opaque white. Within the body of the host they remain mainly confined in the abdominal area and as stated before they never mature if there are too many of them within one host. The factors determining the length of this stage are temperature and humidity. In December and January the length of the egg and larval stages varies from 28 to 34 days in January and in February it has been found to be 25 days. But the gradually rising temperature in spring exerts its stimulating influence on its vital functions and reduces the period to 17 days in March and still further to 12 days in April.

Pupa. When a larva matures it punctures the skin of the host and gradually makes its way out until the skin round the aperture sits as a collar on the constriction between the abdomen and the pouch of the emerging larva and it is held firmly in position so as to be able to spin its cocoon. Then it commences to spin small loops just in front of the head, by moving it in different directions and gradually extends it, over the head, backwards and sideways until the anterior half of the body is covered with the half formed cocoon [Plate XXVII, Fig. 1 (4)]. The larva then stops spinning and continues to wriggle and twitch its body until the pouch is extracted out, which by this time is reduced to half its original size. It then turns completely round, *i.e.*, the posterior end is thrust into the half-formed cocoon and the head is brought towards

the body of the host. It then bends its head upwards and begins spinning again at the unfinished end until the second half is completed when it has an elongated oval shape with the anterior end more pointed than the other. [Plate XXVII, Fig. 1 (6)]. The cocoons are formed side by side in a compact mass and rest loosely on the body of the host, which by this time is reduced to about half its original size. [Plate XXVII, Fig. 2 (1)]. The host becomes motionless as soon as the larvæ within commence to make their way out, and by the time the cocoons are finished, about 12 hours, it dies. The length of the pupal stage varies considerably at different seasons of the year. In November it varies from 9 to 12 days, in December it is 17 days, in January and February 11 days and in March 8 days. Towards the end of March or early in April, when the temperature rises considerably and relative humidity falls, the grubs within æstivate and they come out as adults in autumn next under normal conditions. In the hills, emergence from æstivating cocoons commences with the break of the South-west monsoon in June. An adult insect makes its way out of the cocoon by cutting out a circular disc at one end which hangs like a lid.

Adult. There is no marked external character by which the male and female insects may be distinguished, except in the lengths of the antennæ which in the male is somewhat longer than that of the female [Plate XXVII, Figs. 2 (2, 3)]. They become active within an hour after emergence from cocoon and begin to pair. The length of the adult stage is about 3 to 4 days after which they die irrespective of whether egg laying has been done or not. As regards their selection of host insect a gravid female parasite lays eggs only on caterpillars of *Agrotis ypsilon*. Several attempts have been made to breed them on Tobacco caterpillar (*Prodenia litura*) but always without success.

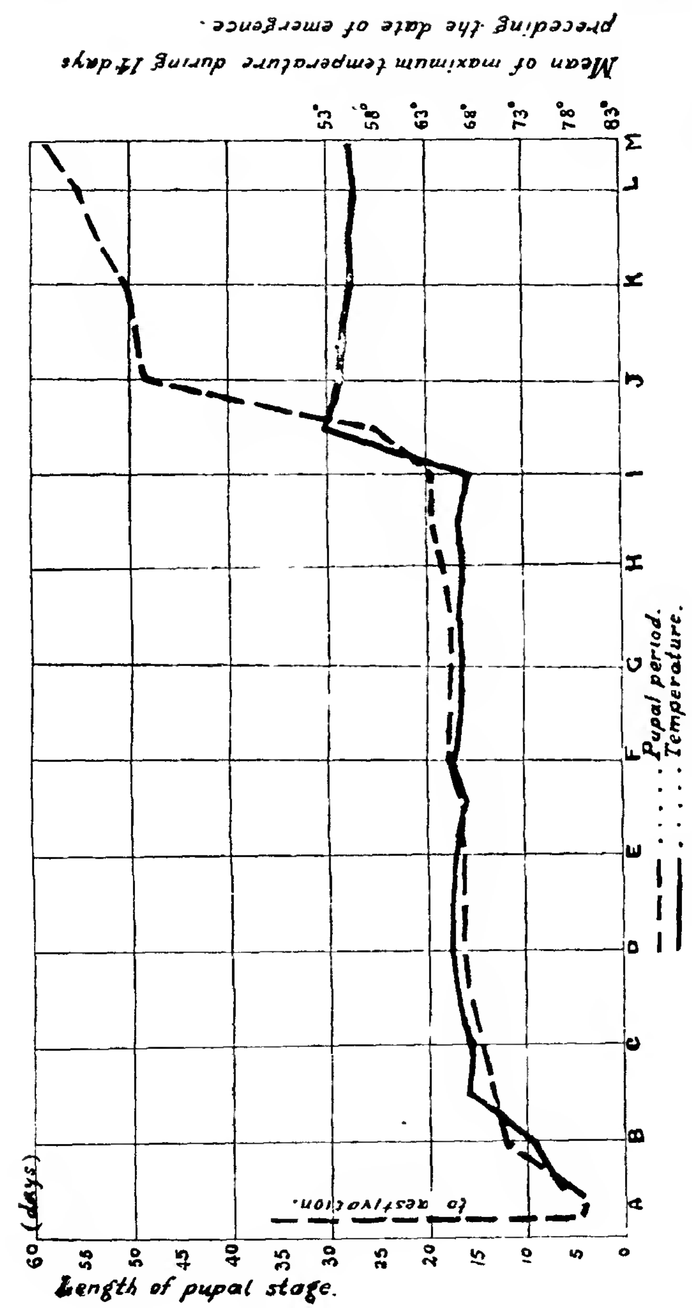
II. Life cycle under field conditions.

The adults first appear in the field presumably with the first brood of host insect, *i.e.*, in September or October when the flood water is about to drain away, but its presence is not noticed until it has passed through a few broods and attacked the destructive second brood of the caterpillar pest. Among the first brood caterpillars it is only rarely that a parasitized one is found but in November and December the number of parasites increases so enormously that 50 to 70 per cent. of the late brood caterpillars are found to be affected. This high percentage of parasitization in the second brood of the caterpillar pest has no beneficial effect on the crop as when the caterpillars succumb to their attack the damage to the crop has already been done. The parasite remains active

up to February and March but with the rising temperature and gradually decreasing humidity their functional activity, which reaches its maximum in February and March, is reversed and the grubs after spinning the cocoons go into æstivation. The æstivating cocoons lie scattered all over the attacked area in large numbers but the majority of them are killed off by the adverse conditions obtaining in the *chaur* lands, *viz.*, extremely dry hot winds in April and May but submergence under flood water for about two months in the rains. It is only those few formed in favourable situations which survive through summer and the rains. The favourable spots are the deep cracks in the soil, with which the whole surface is interspersed, way up on the comparatively higher land bordering the flooded areas and beyond the flood water level. The moisture content of soil in such cracks at different depths was determined in May 1919 and was found to be 9·5 per cent. at a depth of 6 inches, 16·6 per cent. at 12 inches and 21·0 per cent. at 18 inches. Samples of soils were collected on a day when the temperature in shade was 108°F. relative humidity of the atmosphere varied from 10 to 20 at midday and there had been no rain during the previous 15 days. As regards temperature it should be quite favourable at such depth as in high lands the difference between the temperature of soil at the first inch and at a depth of 18 inches is about 18°F. in May. The conditions at the bottom of the cracks are therefore favourable enough for keeping the cocoons alive but not for the development of the grubs within or for the emergence of the adults which require a much lower temperature. When therefore the caterpillar pest first appears in the field under normal conditions in September or October the number of surviving parasites is far too low to be of any effective use in controlling the first brood. With the appearance of the host insect however, they continue to have brood after brood until their number is sufficiently large in December to enable them to parasitize 70 per cent. of the enormously large destructive second brood of the caterpillar pest.

III. Reactions to Temperature and Humidity.

With a view to utilizing the parasite as a means of controlling the caterpillar pest, its reactions to temperature and humidity are being studied in the Insectary at Sabour for the last two years. The object of the work has been to determine the factors controlling its æstivation and emergence definitely so as to be able to have in hand enough parasites, readily emerged, in September or October for liberation in the affected areas just when the first brood of the caterpillar pest is noticed there. Under ordinary conditions it is not possible to have a large number of adult parasites at that time as they cannot be reared through the summer



Graph showing the relation between temperature and the length of the pupal stage of the parasite

and the rains on account of the heat which is above the temperature of effective rearing of either the host or its parasite. It was therefore decided to try to control its æstivation and emergence if possible by artificially regulating the moisture and temperature conditions of its surroundings. It may be said that as regards temperature there is for each insect (or animal) a certain degree of heat which is most favourable to its well being and obviously every rise or fall of temperature above or below this point must to a certain extent be injurious to it. It may be also taken as granted that the well being of an insect depends far more essentially on the variations and extremes of temperature than on the absolute degree of heat. From the very freezing point, a rising temperature begins to exert its stimulating influence on the vital functions of every living thing up to a certain point when the functions are at the highest possible stress under the optimum temperature which of course is different in different animals. If the heat rises above this optimum, the effects are reversed, the functional activity is more or less reduced, till at last a comatose condition is reached just preceding the death of the organism, which ensues under too great heat. The same may be said to be practically the case with humidity. Its effect on the speed of animal metabolism is extremely variable and different insects have probably different optimum points of humidity. In many cases moist air is known to retard the development of insects while in others it seems to hasten it. From a large number of observations made on parasite cocoons under different temperature conditions in the Insectary it has been seen that at about 80°F. (this is the mean of the maximum temperature for two weeks preceding the emergence from the cocoon) the functional activity of the parasite pupa is the greatest and the length of the pupal stage under such condition is 5 days. If the temperature goes higher the grub within becomes dormant and if it falls below it the pupal period gradually lengthens out until at 53°F. it is as long as 58 days. The relation between temperature and the length of pupal stage is shown in the graph. (Plate XXVIII). Unfortunately it has not been found practicable to maintain the mean of the maximum temperature at a point considerably below 53°F. in which case it might have been possible to determine the lower temperature limit for the functional activity of the parasite. As regards the higher limit it has been seen that when the temperature is allowed to rise above 85°F. the emergence of parasites from cocoons completely stops. This is clearly shown in the graph (Plate XXVIII), in which the curve representing the lengths of the pupal stages of a certain number of insect has been compared with that representing the corresponding temperatures influencing the same. The

heavy left hand vertical line represents the number of days (pupal stage) and the right hand one, temperature. This temperature is not absolute but is the mean of the maximum temperatures for 14 days previous to the emergence of the adult parasite, to which a cocoon has been exposed. The vertical lines A. B. C., etc., representing each one cocoon, have on them shown lengths of the pupal stages of the different cocoons and their corresponding temperature. It has further been seen that when the emergence stopped for some cocoons on account of the rise of temperature above 85°F. the functional activity of the pupæ may be revived even after two months, if they are again placed under favourable temperature conditions (*i.e.*, below 80°F.). It shows that any rise of temperature above 80°F. if it is too high, only arrests the development temporarily, but the vitality is not lost as it may again be revived by reintroducing the favourable conditions. So far, therefore, as temperature is concerned it has been found possible, by regulating it, to make the parasite pupæ or grubs emerge as adults, at any desired time, provided of course due time allowance is given to the æstivating parasite by way of exposure to favourable temperature conditions. Now it remains to find out how best it is possible to force the parasite cocoons to become dormant, *i.e.*, to get into æstivation. This may probably be accomplished by exposing them to continued low temperature much below 53°F. but since it is not economical to maintain it for several months, it has been found necessary to handle the problem by modifying humidity which is more easy to control than temperature. An experiment on this line is at present being conducted but it has not been completed yet. From this experiment it was been seen that when a freshly formed cocoon is kept in a vessel maintaining a constant Relative Humidity of 5°, it becomes dormant. Adult insects emerged from a check lot of the same batch of cocoons in 15 days but the treated cocoons on being taken out of the vessel after two months were on examination found to be still living as healthy grubs within the cocoons in a dormant condition. Trials are at present being made to revive them and make them emerge as adults under favourable humid conditions. If this proves successful the problem of utilizing this parasite as a means of control will resolve itself into :—

(1) Collection of parasite cocoons from the affected area in February and March when they are common there or to breed them out in the Insectary in large numbers in winter, when both the host and parasite are active and to enforce dormancy on them by placing them under proper dry conditions and

(2) to make the adults emerge from the dormant cocoons in September or October by exposing the whole lot of them, in due time, to favourable temperature conditions.

The second part of the work has already been done satisfactorily and as regards the first a few more months work is necessary to come to a definite conclusion and if as satisfactory and definite a result is obtained in this case as in the first, it is hoped that it will be possible to control a very serious pest of the Province by a much cheaper and more effective method than has hitherto been employed.

At Pusa we have been able to carry *Agrotis ypsilon* on through the hot weather into August.

I could not carry it through the summer. I tried all favourable conditions. It is drier South of the Ganges than North of it. Our humidity goes down to 10-12 per cent. Pusa, I understand, does not go below 25 per cent.

We tried experiments on prolonging the development of resting longicorn larvæ by desiccation and found that though we could delay it for a few weeks, further delay resulted in death and we could never postpone it until next year. Desiccation went on for several months during the resting period of the larvæ, which lost up to 75 per cent. of water before they died.

Where did you get the Shillong larvæ of *Agrotis ypsilon* ?

From potato on the farm at Upper Shillong.

I have never seen *Agrotis ypsilon* in Shillong. Were there any parasites on the specimens from Shillong ?

These specimens were reared in the Insectary and the adults proved to be *A. ypsilon*. There were no parasites on the Shillong larvæ.

In the Plains of Assam we get the caterpillars of *A. ypsilon* very commonly and also the parasites.

There are two Braconid parasites in Bihar. Which one do you get in Assam ?

The one with the white cocoon.

The one with the brown cocoon is more common in Bihar.

20.—A PRELIMINARY LIST OF THE INSECT PESTS OF MESOPOTAMIA.

By Rao Sahib Y. Ramachandra Rao, M.A., F.E.S., *Assistant Entomologist, Coimbatore.*

Mesopotamia in its strict sense refers to the land between the two rivers, the Tigris and the Euphrates. The land under British occupation at present and going under the name of Mesopotamia is the great low-lying plain stretching from the highlands of Kurdistan in the North to the shores of the Persian Gulf, and lying between the highlying Persian Plateau on the East to the tableland of the Arabian Desert on the West. Geographically it consists of two distinct portions—a northern half extending down to a few miles north of the latitude of Baghdad and consisting of a region of undulating steppe land—covered with grasses and beautiful flowering shrubs in spring and dry during the rest of the year. It is known as "Al Jezirah" or the Island. The Southern known as "Iraq Arabi" is a region of a dead level alluvial flat, stretching from above Baghdad down to the sea. Excepting the banks of rivers and the neighbourhood of canals which are marked by groves of the Date Palm and clumps of Poplars, Iraq is absolutely devoid of trees and almost the only vegetation noticeable on this vast plain is the ubiquitous Camel-thorn (*Agool*, Ar.) and the "Shoq" (*Prosopis*). Lower down, where the Tigris and Euphrates annually spread their overflowing waters over all the lowlying portions, the plain dissolves itself into a region of permanent marshes covered with rushes and tall grasses. The soil is a fine alluvium which is extremely fertile and stands in need of little else than the fertilising waters of the twin rivers to produce an abundant harvest. That the land was in ancient times intensely cultivated and highly prosperous is beyond doubt, as is indeed fully testified by the ruined banks of ancient canals which seam the country in all directions and serve as the only landmarks in an indescribable waste as limitless as the sky. The marvellous find of the most ancient library and inscriptions known to man written in the Cuneiform Script—the deciphering of which has been a romance in the history of archæology—has disclosed to the world what a highly developed standard of civilization had been attained in the times of the ancient Babylonian and Assyrian Empires. Various Kings of Babylon have in their inscriptions commemorated the construction of numerous famous canals many of which may be recognized in their ruined condition even at the present

time. Mesopotamia has been referred to by various Greek and Roman writers as the granary of the world, indicating a highly developed type of cultivation, and even as late as the period of Harun-al-Rashid—the balmy days of the delightful Arabian Nights—the country appears to have been exceedingly prosperous. Historians affirm that the transformation of this delightful picture into the present scene of desolation is due to the inroad of hordes of barbarous Mongols under the Chieftainship of Hulagu who about 1230 A. D. swept through the land, plundered the city of Baghdad and destroyed the canals, leading not only to the destruction of the cultivation but also to the inundation in succeeding years of high floods of large areas of land—now converted into permanent marshes. After several successive periods of anarchy, the land came under the subjection of Turkey, but partly due to the distance of this province from the capital and partly due to the general ineptitude of the Turk the development of the resources of this rich tract remained in abeyance. It is only recently since the British occupation that the question of the development of irrigation has begun to receive attention and, if political conditions allow of it, there is no reason why this province should not again attain to its ancient glories.

Seasons. Mesopotamia lies really in the Temperate Zone, and enjoys a mild winter resembling that of the South of Europe, but as it falls within the area of the rainless arid zone passing from the Sahara through Egypt and Arabia into Mongolia, it is subject to an excessively hot summer. There are four definitely defined seasons as in Europe: spring, summer, autumn and winter. In winter temperatures as low as 20°F. may be experienced while in the north near Mosul there is regular snowfall in winter. The scanty rain amounting to an average of 5 inches in the year is received in the winter months, the largest fall being in March. There is a well-defined spring, most noticeable in the North. The summer is practically rainless and is subject to hot desert winds and very high temperatures, reaching to 126°or more at Basrah. The climate cools down in autumn which imperceptibly merges into winter.

Cultivation. Being mainly a rainless tract, it is very uncommon to find crops raised solely by the help of rain, except in the extreme north near Mosul and the sub-montane tracts along the Persian Hills, where a heavier rainfall as well as snowfall is experienced. In these places wheat and barley are the crops mostly raised. In the rest of the country, cultivation is entirely dependent on irrigation. Around Basrah the periodical rise in the level of the river water owing to the influence of the tides is taken advantage of for irrigating the abundant Date groves. Along the Euphrates area and in the Diyalah River area around Baqubah,

there is a regular system of canals leading water from the rivers to the cultivated areas. In addition to these, there are at various points along both the rivers certain canals in which water is available only in seasons of high flood which occurs regularly in April-May. In Sub-montane tracts springs rising in mountain-sides are exploited for raising various crops. The most usual means of irrigation is however, the water-lift—either the Persian Wheel or the Mhote driven by ponies (Ar. *Cherid*), or the pumps driven by Oil-engines. Owing to its dependence on river water, it will thus be seen that, except in the case of the regular irrigation canals, cultivation is confined mostly to the riverbanks.

The most predominant element of Mesopotamian Agriculture is the culture of the Date Palm. The Date Palm forms the wealth of the Arab and is a dearly cherished object regarded almost as one of his children. The continuous belt of Date forest extending from the mouth of the Shatt-al-Arab for a distance of nearly 90 miles up the river up to very near Kurnah, is unrivalled in the world both in extent and quality. In addition to the Basrah area, there are numerous patches of Date cultivation both along the Euphrates and the Tigris and in numerous isolated localities like Mendali and Bedrah. The Date Palm does not flourish further than 50 or 60 miles north of Baghdad owing to the occurrence of heavy frosts. Next to the Date is wheat and barley which are the staple grains of the land. Paddy is grown under canal irrigation and in marshy situations near the Basrah area, while in favourable situations like B'aqubah large areas of fruit-trees are noticeable, the chief fruits being Apricots, Peaches, Nectarines, Pomegranates, Figs and Grapes. In the neighbourhood of large towns immense quantities of vegetables are grown for the supply of the local markets, the chief vegetables being turnips, cabbages, cauliflower and beet in winter and ladyfingers, brinjals, cucumbers, radish and beans in summer. Of late the activities of the Agricultural Department have demonstrated the great possibilities of cotton as an industrial crop in Mesopotamia.

Insects in Mesopotamia. Contrary to the generally accepted view, insects are by no means scarce in Mesopotamia. In summer, however, owing to the extreme heat, several of the insects are in a state of æstivation, while the extreme rigours of the winter frosts compel many other insects to undergo a state of hibernation. The advent of the spring, however, is an occasion for a very remarkable outburst of life. Butterflies are seen fluttering in the emerald green fields, varieties of rosechafers are noticeable on flowers, and the hum of the bees is everywhere in the air, while the abundance of nocturnal insects that crowd around the dinner table at night and persist in committing suicide in various viands makes life a burden in the spring months. The general character of the insect

fauna appears to be Palæarctic and of the south Mediterranean type. A general collection of insect was made as far as time permitted, and is of course by no means exhaustive and the non-availability of literature in general and on the Mesopotamia fauna in particular placed me in the position of a man groping in the dark.

Insect-pests of Mesopotamia. It may perhaps be readily conceded that a single year cannot be considered to be a period long enough to make an exhaustive study of the insect pests of any province. The task was especially difficult in a country which was at best just beginning to get settled and was before long unfortunately in the throes of an internal rebellion. As falls to the share of pioneer workers, there was a scarcity of apparatus in the earlier part of the period, and throughout, a lack of of help in routine work. I trust the above adverse circumstances may be held to be sufficient excuse for the imperfect nature of many of my observations.

A certain amount of entomological work of economic interest was found to have been done previous to my arrival in Mesopotamia. Mr. (then Captain) P. A. Buxton of the R.A.M.C., had been deputed to report on a disease of the Date Palm causing a good percentage of young fruits to dry up and drop off. His observations were published as a Bulletin of the Agricultural Department, Mesopotamia, in 1919. These have reappeared in a modified form in a recent number of the Bulletin of Entomological Research. In addition to the pests on Date, he has also worked on a Lymantriad pest on Figs and certain other injurious insects on crops. Major C. R. Winshurst, who was Government Entomologist at Baghdad till May 1920, had made various observations which have been incorporated in the Annual Report of the Agricultural Department for the year 1919-1920. I am indebted to these two authors for information regarding several of the pests.

The following is a list of pests found on the various crops either collected by me personally or reported officially from the various parts of the country. It is greatly to be regretted that, as many of the insects belong to a type of fauna different from the Indian, the major number cannot be identified with any certainty even with the help of the large collections at Pusa.

1. *Date.* The most serious pest of the Date Palm in Mesopotamia is the " Hashaf " Moth ; young fruits are bored into by a small caterpillar, whereby they turn red, dry up and drop down ultimately. The loss according to Buxton may be as much as 50 per cent. Buxton refers to his pest as a Gelechiad, but he did not rear the moth. Specimens of

moths reared and brought here with me are pronounced by the Imperial Entomologist to belong to the Family Cosmopterygidæ.*

2. The stem *Longicorn* : "*Chernib*" (*Arabic*). This Longicorn emerges in June-July and lays eggs under the leaf-bases or in cracks in the stem. The grub bores into the leaf-bases and into the stem and when present in large numbers, the tree is weakened and is liable to break in high winds. This is wrongly identified by Popenoe as *Rhynchophorus*, which does not occur in Iraq.

3. *Oryctes elegans* : "*Khun-fasanah*" (Ar.) : This beetle is smaller than *O. rhinoceros* and can be easily differentiated. It bores into the shoots of Palms and has also the habit of breeding on the tops of palms, the grubs being found boring into the stalks of developing fruits.

4. *Date Fulgorid*: "*Man-en-nakhl*" (Ar.). This small bug breeds in large numbers on the Date Palm, the young ones feeding on the fronds and excreting large quantities of honeydew. There are two generations in the year.

5. *The Date Mite* : *Oligonychus simplex*, according to Buxton : The mite spins large webs over clusters of developing fruits and prevents them from ripening.

6. *Scale Insects* : There are three Scales noticed on Dates, which are found in fairly good numbers both on young and old plants, but do not seriously affect the health of the palms as reported in cases of imported plants in America.

1. *Parlatoria blanchardi* on leaves and leafstalks.
2. *Phœnicococcus marlatti* found hidden between the leaf-bases and the trunk.
3. A *Lecaniid* Scale found on the leaves and stalks and on fruits in some cases.

7. *Ephestia* sp.: Found boring in stored fruits and in windfall dates.

Wheat and Barley.

1. *The Stem Fly.* Probably *Hylemyia coarctata* : attacking young seedlings of Barley and Wheat.

2. *A Leaf-miner Fly* : in leaves of wheat.

3. *The Hessian Fly* ? attacking side-shoots of plants.

4. *Cephus* sp. The Stem Sawfly. Boring into the stems of maturing plants and cutting them close to the ground.

5. *Eurygaster* sp. "Sun" pest of wheat—a serious pest in Mosul and the submontane tracts. The adults pass both the summer and the winter in the soil and lay eggs on wheat in spring. The young bugs

* Since identified as *Batrachedra amydraula*, Meyr.—Editor.

suck the sap from developing grains and cause immense destruction. Reported from Russia, Turkestan and Persia.

6. Two other bugs unidentified—also reported to have similar habits as *Eurygaster*.

7. *Decticus albifrons* : " Abudubela " a Locustid grasshopper, found also in Italy, attacking the earheads of wheat. It also damages vegetables, peas and fruits.

8. *Locusts*. The Moroccan Locust : *Dociostaurus maroccanus* is a serious pest in the Mosul Vilayat, breeding in the Steppes and flying over to cultivated areas.

9. *Thrips*. Found in large numbers on developing grains.

10. *Tylenchus tritici* : The ear-cockle of wheat.

Sorghum and Maize.

1. *Sesamia* sp. probably *cretica*, boring in stems. *Chilo* is completely absent.
2. *The Stem-maggot*—on Juar, evidently identical with the Cholam Fly of South India.
3. Jassids on juar leaves.
4. *Cirphis loreyi* : on leaves.
5. *Chapra mathias*, on leaves.
6. *Decticus albifrons* on maize and *Panicum miliare.*

Lucerne and Bersim.

1. *Laphygma exigua*—a serious pest.
2. *Hypera variabilis* : on lucerne.
3. Leafmining Fly.

Cotton.

1. *Earias insulana*—occasioning much damage to bolls.
2. A Cutworm—probably *Euxoa segetum.*
3. *Laphygma exigua* on leaves and flowers.
4. *Oxycarenus* sp.
5. Aleurodid.

Sesamum.

Lygœus pandurus on fruits.

Linseed.

Heliothis obsoleta on fruits.

Sannhemp.

1. *Utetheisa pulchella.*
2. *Decticus albifrons* on pods.

Pulses.

1. *Prodenia litura* on greengram.
2. *Laphygma* on *Vicia faba.*
3. *Xylina exoleta,* on *Vicia faba* in fairly good numbers.
4. Two species of Aphis on *Vigna sinensis.*
5. *Bruchids* :
    1. *Bruchus lentis* ? : on Lentils.
    2. ,, *rufimanus* ? on *Vicia faba.*
    3. ,, *quadrimaculatus* ? on *Vigna sinensis.*
    4. ,, *affinis* on imported peas.
    5. ,, *vectabilis* ? on Liquorice pods.

Vegetable Crops.

Turnips
Radish
Cabbage
Cauliflower
Mustard, etc.

1. *Aphis brassicæ.*
2. A Black Aphis.
3. *Bagrada picta.*
4. *Plutella.*
5. *Hellula undalis.*
6. Cetoniad on flowers.

Beet and Spinach : The Mangold Fly—mining into leaves (*Pegomyia* sp.).

Potato : *Phthorimœa operculella.*

Brinjal :

1. A leafminer—*Phthorimœa ergasima.*
2. *Epicauta* sp. in small numbers.

(*Epilachna* conspicuous by its absence).

Chillies and Tomato : *Nezara viridula.*

Cucurbits :

1. *Aulacophora foveicollis.*
2. *Epilachna* sp. (*dodecastigma*).
3. *Myiopardalis pardalina* : in Sugarmelon—cucumber.
4. Aleurodes sp. a serious pest on sugarmelon.
5. Berytid on Lagenaria.

Lady's fingers :

1. *Laphygma.*
2. *Earias.*
3. *Aleurodes.*

Onions : Onion fly.
Sweet Potato : *Herse convolvuli.*
Castor :

1. *Phycita* sp. near *clientella* ? very bad.
2. Mites on leaves.

FRUIT-TREES.

Apple :

1. The Codlin Moth. *Cydia pomonella.*
2. A Tingid Bug.
3. Cigar casebearer—a Microlepidopteron.

Apricot :

1. The Peach Moth.
2. Codlin Moth.
3. Buprestid Borer in twigs and stems.
4. The bark beetle (Scolytid).

Peaches and Nectarines :

1. Peach Moth.
2. Codlin Moth.
3. Peach Aphis.
4. The Buprestid.

Quince :

1. Codlin Moth.
2. a Pyralid ?

Citrus spp. : No pests whatever—except *Gryllotalpa gryllotalpa*—reported to damage young Citrus seedling by Mr. Paranjpye, the Assistant Botanist.

Fig :

1. The Fig Moth—*Ocnerogyna amanda.*
2. *Lonchæa aristella*, the Black Fig Fly.

Grapevine :

1. The Hawkmoth—*Theretra alecto.*
2. A Mealy bug.

Mulberry : A Scale.
Olive : Scale.
Zizyphus :

1. *Tarucus theophrastus.*
2. Aleurodid.
3. Scales.

Locusts :

1. *Schistocerca peregrina.*
2. *Dociostaurus maroccanus.*
3. *Caloptenus* sp. ?

The above observations, meagre though they may be, serve to show the character of the Insect Fauna to be found in a country occupying the interesting position of a half-way stage in the land route between Europe and India. A knowledge of the Insect inhabitants of this country is, however, neither simply of academic interest nor even of purely local significance: it is of great importance from an international point of view. In view of the trade that might be expected to spring up between India and Mesopotamia, as a result of British influence, it is important to recognize the danger of an introduction into either country of pests from which it was hitherto free. As regards Mesopotamia, the most important insect to be guarded against is the Pink Bollworm, in view of the great possibilities of cotton cultivation. Again, the Orange and other Citrus varieties in Mesopotamia have been found to be remarkably free from insect pests. It is not possible to say whether this is due to the extreme climatic conditions of the country or due to the immunity of the varieties, but it is incumbent on the Government to prevent the entry of the numerous pests Citrus trees are subject to in India and America; and again, in view of the possibilities of Fruit-growing, the Mediterranean Fruit-fly is an insect the entry of which from the West should be legislated against. On the other hand, there are several European pests of notoriety which are not yet found in India, but are noticeable in Mesopotamia. The Codlin Moth of apple, the Black Fly of Fig, *Tylenchus tritici* (ear-cockles) of wheat, the Hessian Fly of wheat, and the wheat stem sawfly, and the Melon fruit-fly (*Myiopardalis pardalina*) are a all instances of insects which India would be thankful to be free from. Bruchids like *Bruchus rufimanus*, *B. lentis*, etc., are also insects likely to be imported. With further observations on economically important insects, instances of similar dangerous pests are likely to be multiplied, and it is therefore important that early steps should be taken in either country to guard against the invasion of such pests.

In conclusion, I take this opportunity of thanking Captain Roger Thomas, Acting Director of Agriculture, and Captain J. F. Webster, Acting Deputy Director of Research, for whose kind help and advice throughout my stay in Mesopotamia I am much indebted.

It is very important for us to know whether this Hessian fly identification is a correct one. The fly was originally imported into America with straw and might similarly reach the Indian wheat areas through Karachi. The observation regarding the Codlin Moth is interesting as it is not definitely known from India. If Mesopotamia has only recently legislated against Pink Bollworm it is probably too late, as much cotton seed has already been imported. We had an inquiry regarding sugarcane which was imported at Karachi from the Persian Gulf. As it was only imported for eating purposes and there is no cane grown around Karachi, we replied that there was no objection to the trade. We now know that *Sesamia* occurs on cane, in Mesopotamia, but that other borers have not been found.

21.—SOME OBSERVATIONS ON THE CONTROL OF FIELD RATS IN THE PUNJAB.

By M. A. HUSAIN, M.A. (CANTAB.), *Government Entomologist, Punjab, and* HEM SINGH PRUTHI, M.SC., *Assistant Professor of Entomology, Punjab.*

The rat is recognized as one of the serious animal pests all over the world. While in almost all other civilized countries there are various organizations like Rat Clubs, Rat Days, etc., to keep this animal down, in India, whose main resources lie in Agriculture, very few people have tackled this problem and that too exclusively from a sanitary point of view.

The population of this pest in this country is enormous and Major Kunhardt's estimate of 800 millions of individuals seems to be quite modest. As regards the quantity of food that a rat eats in a day, it has been observed that on an average one individual consumes about one chittack of wheat, hence, even on the basis of Kunhardt's estimate of the rat population, this pest causes an annual loss of 9,125,000 maunds of grain, worth about Rs. 456,250,000.

The rat that generally occurs in the fields of the Punjab is *Gerbillus indicus*. It is a pretty animal with dark brown back, and white belly. Its ears are thin and hairless, eyes prominent, and tail long, ending in a pencil of black hairs. It is nocturnal in habits and is very rarely seen outside its burrow during daylight.

A rat burrow is seldom straight. Often it is circuitous and ingeniously constructed. It is provided with more than one outlet and the principal entrance has several (2-10) small inlets which sometimes cover an area of 15 square yards round it.

The number of rat holes in an acre is very variable, depending chiefly on the nature of the soil, the crop growing, the mode of irrigation and the period elapsed since the last watering. Burrows are more numerous in sandy and loose soil than elsewhere, and more abundant in high lands and borders of cultivated fields, where irrigated water cannot reach, than on lowland. Under normal cultivation, the canal irrigated areas have on an average 7, well-irrigated 11, and '*barani*' lands 2 to 4 burrows per acre. Sometimes, however, the number is very large; at Chillianwala (District Gujrat) for instance there were as many as 90 burrows per acre in some uncultivated and deserted fields.

All the burrows are generally not occupied by rats. Some 30 per cent. are often deserted and are inhabited by such animals as lizards

and snakes. The occupied burrows can easily be distinguished by the presence near their mouths of freshly outturned soft earth with the foot prints of the rats on it.

It is very difficult to state accurately the number of adult rats that live in one hole. The fields were observed when being watered, and as many as five to seven could be counted coming out of one burrow but during the poisoning experiments, if the rats died outside, generally one or two were found near the mouths.

The rat is an omnivorous animal feeding on all sorts of food available. It destroys grain in every stage, in the stock, granary, bins, mill, ship-hold, as well as grain that has been sown and is germinating. It is famous for its mischievous nature and takes to its burrow anything, edible or otherwise, that comes in the way. During the last four months (September-December 1920) among other things, soft cotton, paper, silk and cotton cloths have been recovered from their homes. They not only directly cause injury to grains and standing crops, by eating them up, but spoil ten times the amount that they actually consume, by cutting the roots and thus felling the whole plant, spreading cotton on dirty ground, etc. They dig holes in the banks of canal *khals* and cause heavy losses, by making water run where it is not wanted and thus spoil the crop and waste the water as well. It is possible that canal breaches are sometimes the work of this animal. After rain one can easily see the damage done by it to the roads on the canal bank. Some of the pits that appear are the result of its activities.

Rats cause havoc both to the spring and autumn crops. Wheat grains are its favourite food. When the grains are sown this animal comes out at night and eats up the seed. In Sargodha district during the last winter, the poor farmers had to sow twice or thrice to get a crop. However, when seeds have once germinated, there is very little danger unless there is absolutely nothing else for the rats to eat.

Cotton. This crop also suffers a good deal. At Rakh Pindi Jalal (Hafizabad District), some burrows in the cotton fields were dug open and from every one of them was recovered four to ten chittacks of cotton which was being used to make their nests warm and soft. The rats had torn the lint to get at the seeds whose contents had been eaten up. The cotton thus spoiled of its seed is absolutely useless for ginning purposes.

Sugarcane is a choice food of this animal. Its pulpy base under the soil is gnawed, with the result that the canes fall down and dry up. As many as 30 out of 100 were once found damaged this way.

Maize like wheat, suffers heavily before germination. In this case, too, sowing is said to be rendered impossible sometimes. While after

germination the wheat is almost free, the pulpy maize stems still attract the rats.

Grams, Peas and Vetch. These crops are ravaged from the time when they are sown until they are harvested. When the plants are high and have pods, the rats jump up, bend down the shoot and eat out the soft seeds from the pods.

Control.

Poisoning, Fumigation and Trapping are the three methods that are generally advised for the control of this pest.

Poisoning. Various poisons were tried. Strychnine (Sulphate), Barium Carbonate, Plaster of Paris, Arsenious Acid. The poison was mixed with a bait consisting of wheat, gram, grains of crushed oats, etc. It was observed that field-rats, unlike the house-rats, do not relish flour.

To see the effect of poison, all the rat burrows were closed one day, and those which were found reopened next morning were taken to be inhabited. Poisoned bait was put in them and they were subsequently closed. In those that remained closed the next day, presumably the rats had died; otherwise, if living, they would have reopened them during the intervening night. (In every experiment some of such burrows were actually dug open and dead rats were found inside). Those that were reopened the next morning after treatment did not all contain live rats, because some of the rats after eating the poisoned bait did not die immediately, especially in the case of poison other than strychnine, but came out of their homes as usual and then, after some time, when the poison began to have its effect, they went in and died. To find out the number of reopened burrows which had rats dead in this way, all of them were closed again without putting anything in them and those that remained closed on the third day had either dead rats or their occupants had run away after eating the bait. So the burrows that were reopened on the next morning after treatment and were simply closed and again found reopened the third morning, had living rats.

Rats from burrows treated with strychnine mostly died outside their homes. This was especially common in the summer season. But in the case of other poisons, the percentage of those that died outside was very small.

STRYCHNINE.

Mode of preparation of the bait. Half a chhitak (1 oz.) of strychnine sulphate was dissolved in three chhitaks of warm water. A thick syrup of sugar (*shakar*; black sugar preferably), was made by heating two

seers of the substance in half a seer of water. Both the solutions were thoroughly mixed and then heated to ensure thorough admixture. Then this mixture was sifted gradually over fifteen seers of gram or wheat which had been previously moistened. The poison was allowed to soak in the grains for some 12 hours.

Some half chhittack of the thus prepared bait were put in every rat burrow which was subsequently closed and was watched next morning. If it remained closed until then, its occupant was taken to be dead.

As will be clear from detailed observations, with strychnine some 89 to 90 per cent. of the treated burrows remained closed. The cost on an average was one anna for eight burrows, excluding of course the cost of labour.

Great care should be taken in the use of this poison. A few crystals will kill even man. So when strychnine is being used, domestic animals, poultry, etc., should not be allowed to leave their pens. Baits should be very carefully handled and placed deep down in the burrows. Satisfactory arrangements must be made for the disposal of dead rats, which die in large numbers outside their burrows. If rats dead of this poison be eaten by any other animal, the latter is sure to die.

Plaster of Paris. The poisoned bait was prepared just like the strychnine bait, solutions were made of Plaster and sugar in separate vessels, both were mixed and sifted over the suitable grain which had been previously moistened. One pound of the Plaster was used with 15 seers of gram or wheat. One seer of sugar was added simply to make the bait more attractive.

The results obtained with this poison were good. On an average 78 to 80 per cent. of the treated burrows remained closed, thereby indicating that the occupants were dead inside.

The poison is fairly cheap and the cost for treating 15 burrows is only one anna. If a large number of burrows is taken in hand at a time, the cost will be still less.

Arsenous Acid. This poison is harmful to man and domesticated animals, so it should be carefully used.

The poisoned bait was prepared just as in the case of strychnine and Plaster of Paris. Four chhitaks of the poison were mixed with 15 seers of the suitable grain and a little sugar was added.

The results obtained were very fair, though not so good as with strychnine and plaster. On an average 74 per cent. of the treated burrows remained closed.

Flour pills (one part poison to six parts flour) of the poison were tried; they did not attract many rats, and most of them remained uneaten. Forty-two per cent. of the burrows remained closed.

Barium Carbonate. The poison is tasteless and pale coloured. When it is taken in, it causes much thirst to the victim.

The flour pills were tried, but they did not give good results. Subsequently the poison was poured over suitable grain as in the case of previous poisons. As in the case of plaster, one pound of posion and one seer of sugar were utilized for 15 seers of gram.

Some sixty per cent. of the treated burrows remained closed and the cost was the same as with plaster, one anna for 15 burrows.

Fumigation.

Fumes of SO_2 (Sulphur dioxide) were introduced into rats' burrows by means of the Ant-exterminator machine. The nozzle of the delivery-tube was put in the main entrance while the other inlets communicating with the burrow were previously closed with earth. The gas was pumped in for three or four minutes and the mouth of the burrows was then closed.

Some 75 of the treated burrows remained closed next morning, but after two or three days some of the burrows (six per cent.) were reopened. This means there was no thorough fumigation in these particular cases.

Carbon bisulphide was tried in a few cases, and was found very satisfactory. As it is unsafe for the Zamindars to use it, detailed observations on its efficacy were postponed for the present.

With regard to the use of any poison, it may be emphasized that nothing is possible without organization. Like other countries, we should arrange for campaigns on extensive scales and for this co-operation amongst the people themselves, and the people and the employees of the State, is essential. It will not serve any purpose to kill rats in a field or so. The work of extermination should be done on large areas at the same time and in an organized manner. District authorities should take an interest. It should be arranged somewhat like this. A *Tahsil* should form the unit of organization. Three days, say the 1st, 2nd and 3rd of every month, should be set apart as rat-days. In every village on the 1st all the zamindars should close the rat burrows present in their fields, and the poisoned bait may be prepared at one place, under the supervision of the head *lambardar*, or a member of the Municipal Committee. On the 2nd, the bait may be carried in carts in all the different directions and the *zamindars* should lay the bait in and subsequently close the burrows that have reopened in their fields. On the early morning before sunrise of the 3rd, they should go to the fields and collect and bury or burn the dead rats that have died outside their homes. As is evident, on all the three days, the rat work will take a few hours only, but this few hours organized work on three days in a month is sure to exterminate the pest. It may be repeated once more that the

Poison.	Date.	Place.	Number of burrows present.	Number of burrows presumably occupied by rats and in which poison bait was put.	Number of burrows out of (5) that remained closed.	Number of burrows out of (5) that re-opened and were closed again without putting anything in them.	Number of burrows out of (7) that remained closed.	Total number of burrows that remained closed.
1	2	3	4	5	6	7	8	9
1. Strychnine	21st December 1920	Rakh Pindi Jolol (Hafizabad).	2,465	1,750	1,126	589	344	1470
2. Ditto	1st December 1920	Chillianwala	920	781	534	197	57	591
3. Ditto	25th November 1920	Sargodha	168	123	108	15	15 (not closed)	108
4. Ditto	14th November 1920	Lyallpur	168	32	8	24	20	28
5. Ditto	15th-21st November 1920	Ditto	163	190	165	25	8	73
6. Plaster of Paris	13th January 1921	Chak 432 (Lyallpur)	85	41	22	19	13	35
7 Ditto	21st January 1921	Lyallpur	85	57	40	17	5	45
8. Arsenious Acid Pill's (flour).	15th December 1920	Rakh Pindi Jolol (Hafizabad).	85	45	5	40	10	15
9. Ditto	27th November 1920	Chillianwala	85	21	10	11	1	11
10 Arsenious Acid (on grains)	16th December 1920	Lyallpur	85	130	80	50	21	101
11. Ditto	15th January 1921	Chak 432 Lyallpur	85	25	18	7	2	20
12. Barium carbonate (pills)	27th November 1920	Chillianwala	..	48	40	22	8	28
13. Barium carbonate (grains)	15th December 1920	Lyallpur	..	30	14	16	4	18
14. Ditto	16th December 1920	Ditto	..	27	11	16	5	16
15 Sulphur fumigation	27th January 1921	Ditto	..	24	17	5	..	17
16. Ditto	21st January 1921	Ditto	..	40	31	9	..	31

Poison.	Number of dead rats found outside the burrows.	Percentage.	Amount of cost.	Area in Acres.	Average cost.	Control.	REMARKS.
	10	11	12	13	14	15	16
			Rs. A. P.				
1. Strychnine . . .	62	86	13 4 0	350	1 anna for 8 burrows 8½ pies per acre.	50 burrows were closed without putting any bait in them. They were closed for successive 3 days and the rats reopened them every day. None left due to disturbance.	
2. Ditto . .	34	80	9 0 0	250	1 anna for 6 burrows or 7½ pies per acre.	Three out of 25 burrows were found closed on 3rd day of disturbance.	
3. Ditto . .	10	90	0 13 0	200	10 burrows for 1 anna .	Occupants of 2 out of 23 left their home on the 4th day of disturbance.	
4. Ditto . .	3	95	0 4 6	6	7½ burrows for 1 anna.		
5. Ditto . .	10	90	1 6 0	10	9 burrows for 1 anna.		
6. Plaster of Paris . .	3	87	0 7 0	..	15 burrows for 1 anna . .	10 burrows. No burrows deserted.	
7. Ditto . .	3	82					
8. Arsenious Acid Pill's (flour).	2	33					
9 Ditto .	4	51	1 4 0	..	11 burrows for 1 anna . .	15 burrows deserted due to disturbance.	
10. Arsenious Acid (on grains)	4	77					
11. Ditto .	2	80					
12. Barium carbonate (pills) .	3	56					
13. Barium carbonate (grains)	..	60	0 7 6	..	15 burrows for 1 anna . .	10 burrows none deserted.	
14 Ditto .	2	61					
15. Sulphur fumigation .	..	79	0 6 0	..	Between 10 and 11 burrows for 1 anna.	1 burrow on 3rd day.	
16. Ditto .	..	76				2 burrows on 3rd day.	

kind of poison itself used does not matter so much as co-operation and organization to ensure *that the uork should be done at one time over large areas*.

Did you try Petrol as a fumigant for the rats in their holes ?

No.

Poison baits must be very dangerous. In Bihar people generally dig out rat burrows for grain, and if the poison has been carried down in the midst of stored grain evil results on eating it might occur.

In the Punjab the cultivators are more civilized and do not do these things.

How do you use Carbon bisulphide ?

We attach a rag to the end of a long pole. This is lighted and a man standing at a distance thrusts the lighted end into the burrow intc which Carbon bisulphide had been poured beforehand.

How do you count the percentage of dead rats ?

That information is given in this paper.

Do you get any rat-fleas ? The Hon'ble N. C. Rothschild will b glad to see any specimens of Indian rat-fleas. The exact distribution c the various species is very uncertain ; and the matter is important o account of their connection with plague.

If any rat-worker comes across cases of Myiasis in his material should be glad if they would send them to me.

22.—RECENT WORK IN FOREST ENTOMOLOGY.

By C. F. C. Beeson, M.A., F.E.S., *Forest Zoologist.*

The principal investigations that have been carried out by the Forest Research Institute during the past two years are studies in the ecology of the borer fauna of (*a*) the *sal* (*Shorea robusta*) and of the trees associated with it in *sal* forests; and (*b*) the teak (*Tectona grandis*) and of some of its associates. The method of inquiry comprises (1) prolonged tours in the forests to study the seasonal occurrence, distribution and environmental conditions of the principal species; and (2) insectary rearing experiments. Material for the latter is obtained on tours by despatching logs of trees dead from natural causes or from fellings. In addition material is obtained from timber-seasoning depôts throughout India, as experiments are now in progress in methods of natural seasoning that are being carried out in co-operation with the section of Forest Economics. Hundreds of logs of various tree species pass through the insectary at Dehra Dun. Illustrations of the breeding cages used are given in the Report of the Third Entomological Meeting.

(*a*) *Sal Borers.* The more important borers are *Hoplocerambyx spinicornis*, *Æolesthes holosericea* and species of Platypodidæ. The former of these has occurred in epidemic incidence as a primary pest killing living *sal* trees; normally it is a borer of felled or killed timber. An account of epidemic is given in an article in the *Indian Forester*, February 1921. [This was described to the Meeting illustrated by diagrams]. It has been found that *sal* trees are killed by mass-attack in years of exceptionally heavy rainfall. In years of rainfall below the average the mortality is less owing, on the one hand, to the increased power of resistence of the tree due to better soil-aeration and on the other to climatic reduction in the incidence of the beetle. The correlation of rainfall and mortality of trees is very striking. The effect of rainfall (as expressed in terms of the water-content of the heartwood of *sal*) on the metabolism of the pupal and early larval stages has been studied and it has been found that the incidence of emergence of the beetle synchronises with the incidence of rainfall in the first few weeks of the monsoon. In a wet year 75 per cent. of the beetles emerge in the first month of the rains; in a dry year this period is prolonged to six to eight weeks. Control measures have been devised from the results of these investigations. Similar work on the emergence periods is being done with other species of borers. It is believed that control of borers of

this class will be obtained by modifications of the felling and seasoning rules.

(*b*) *Teak Borers*. These include *Duomitus ceramicus, Haplohammus cervinus, Phassus malabaricus*, etc. The most important, the notorious bee-hole borer of teak, has been studied entirely in the field in Burma. No living insect has been studied in the Institute insectary, as the borer is a pest of living trees and is confined to the teak forests of Burma. An account of the investigation is about to appear as a Forest Record and is therefore not recorded here in detail. It has been found that the incidence of beeholes in plantation teak is proportional to the girth in even-aged stands, *i.e.*, that the development of the borer is most successful in the most vigorous trees. Annual Incidence Graphs have also been obtained showing that periodic fluctuations occur locally, while the mean annual incidence increases relatively slowly. Fluctuations require correlation with such factors as fire-protection and extraction The effect of fire on the incidence of the borer can be considered on theoretical grounds based on its observed effect on teak regeneration and the evergreen undergrowth of high forest; it is possible to explain the apparent anomaly of badly beeholed teak in forests now traversed by fire and in forests that have been fire-protected for long periods.

The inquiry has advanced beyond the entomological stage and has necessitated the employment of a whole-time officer for the collection of statistical *data* before further research can be carried on.

23.—A NOTE ON THE EFFECTS OF MERCUROUS CHLORIDE ON CULICID LARVÆ.

(Plates XXIX-XXX).

By S. K. SEN, B.Sc.

Amongst the various salts experimented with, with a view to testing their effects on the larvæ of mosquitos, mercurous chloride gave some interesting and rather unexpected results. The experiments had been originally designed to give a series of figures in respect of the comparative effects of salt radicals—both basic and acid—and also of the antagonistic action,* if any, of those salts. But on a preliminary trial the results obtained with HgCl proved to be of sufficient interest to warrant following it up at length; and this seemed all the more desirable in view of the possibilities it opened up as a larvicide against mosquitos. Till now kerosine has practically been the only larvicide in use, but that it does not answer the requirements of an ideal larvicide is proved by the attempts that are still being made by various workers to replace it by a more convenient and less expensive material. As regards HgCl, sufficient trial has not yet been given to it on a field scale to justify its adoption as a larvicide, and what follows is presented merely as an indication of the possibilities, as larvicides against mosquitos, of insoluble salts, non-poisonous to human beings.

The preliminary series of experiments, which aimed merely at qualitative results, were conducted with exceedingly minute quantities of the salt taken by guess. When it was found that even such small doses produced a very deleterious effect on the larvæ, quantitative experiments were taken up with a view to determining the lethal dose. In view of the very small solubility of HgCl (0·002 gram in 1 litre)†, any possibility of osmotic action was excluded, and the assumption was confirmed when a saturated solution of the salt failed to kill the larvæ. As therefore the salt presumably acted in the solid state, attempts were made to ascertain the minimum quantity of the salt necessary to kill the larvæ in relation to the surface-area of water (the salt particles remaining afloat for a fairly long period), as the action of the salt in that case must be practically independent of the volume of water, and the results are shown in Graph 1, representing varying quantities of the salt in relation

* On the lines adopted by Loeb; *vide The Dynamics of Living Matter.*

† Found out by conductivity method; Kohlrausch, *Z. physik Ch.*, 50, 265, 04-05 (quoted by Seidell).

PLATE XXIX

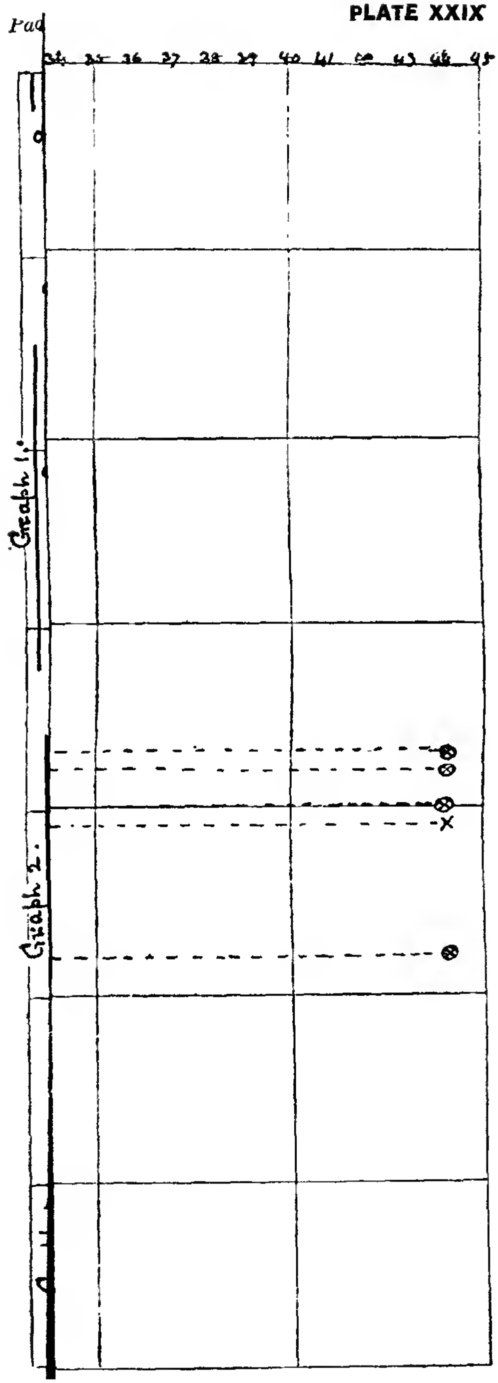
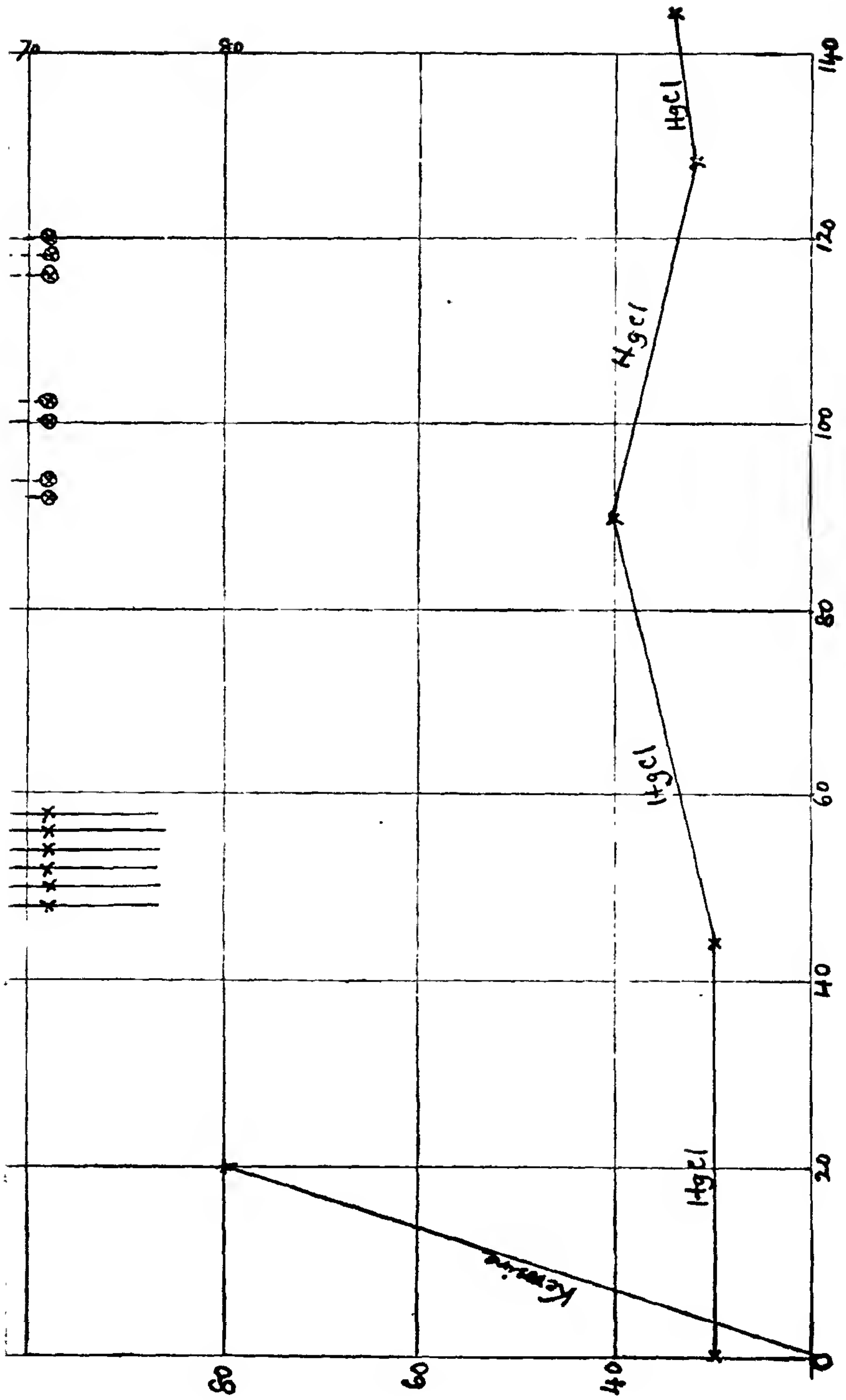


PLATE XXX



Graph 6.

to a fixed quantity of water (100 c. c.); Graph 2, representing a fixed quantity of the salt (0·001 gm.) in a constant surface-area of water (6 inches diameter), but with varying depths; and Graph 3, representing a fixed quantity of the salt (0·001 gm.) in a constant depth of 10 mm., but with varying surface-areas.*

We might assume one or more of the following circumstances under which death might occur :—

(i) Presence of $HgCl_2$ in the calomel as impurity, but (1) the addition of KOH to a saturated solution of the HgCl did not give the yellow precipitate, the characteristic reaction of $HgCl_2$, and (2) saturated solution of the calomel failed to kill the larvæ.

(ii) Gradual conversion of HgCl into $HgCl_2$, but (1) the water in which the salt had been allowed to stand for a considerable period did not answer the KOH test for $HgCl_2$ (2) no traces of the liquid metal could be detected, as the conversion of the salt into $HgCl_2$ would have been accompanied by a separation of mercury, and (3) 0·001 per cent. $HgCl_2$ failed to kill the larvæ (Graph 4).

It is then probably the solid state in which the salt acts. HgCl, even in the solid condition, is said to be capable of acting cutaneously on the human body, the action being hastened with the stimulation of diaphoresis.† It is not improbable that this might also be the case with mosquito larvæ. On the other hand the fact that the pupæ had been, in most cases, found to escape unhurt, lends weight to the assumption that the salt acts orally.

An interesting feature of the results is the exceedingly small quantity of the salt (0·001 per cent.) necessary to kill the larvæ; but the maximum therapeutic dose of HgCl for man being 5 grains only‡, a mere trace of the salt should be sufficient to kill a mosquito larva. On the other hand the maximum therapeutic dose of $HgCl_2$ being $\frac{1}{8}$ grain‡, failure of 0·001 per cent. $HgCl_2$ to affect the larvæ might seem inexplicable, especially in the face of the fact that 0·001 per cent. HgCl, killed them; but this can be explained away by the fact that the attribution of "percentage" to HgCl in relation to quantity of water is meaningless, the solubility of the salt being practically negligible.

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* The results of all the experiments done are not shown in the graphs: only a few typical sets are represented; and in order to emphasize the behaviour of individual larvæ, the customary method of representing the average result has not been adopted.

† *Materia Medica and Therapeutics* (Bruce).

‡ *Ibid.*

A series of parallel observations was carried out on the effects of a few more halogen salts of mercury ($HgBr_2$, HgI_2, $HgCl_2$ and HgI_2 2KI); the two soluble salts ($HgCl_2$ and HgI_2 2KI) were much quicker in action than the other two. This led to an attempt to find out how far the toxicity would increase if HgCl were offered in dissolved condition, and for this purpose a more or less neutral solvent was necessary which would dissolve the salt without the latter having to undergo any chemical transformation. It seemed possible that, in the case of HgCl, such a condition could be realized in pepsin which is capable of dissolving the salt unchanged. In Graph 5 it will be seen that some difference was observed between the effect of a mixture of pepsin and HgCl and that of HgCl only. But in the present state of this inquiry no definite statement is possible.

With regard to the discrepant results, as shown in the graphs, obtained with HgCl, under conditions practically identical, three explanations present themselves:

(1) Quicker death might be the result of comparatively debilitated condition of the larva. It would be hardly profitable to discuss this possibility.

(2) As the salt presumbly acted in the solid state, death must have been dependent on the extent to which the salt particles were distributed over the surface of the water. This seems to be borne out by the fact that in certain cases the action of the salt increased after some days, which was probably the result of thorough disruption and consequent distribution of the salt particles effected by its prolonged contact with water: the fact of a comparatively heavy dose of the salt sometimes taking a longer time to kill the larvæ gives support to this assumption.

(3) It might be the result of variation in atmospheric temperature. Larvæ experimented with in June and July died more quickly than those experimented with in November. It will be seen that the series of lines with 0·001 gm. HgCl in Graph 1 are generally much shorter than the corresponding lines in Graph 4 which refers to winter observations. This difference can hardly be accounted for by any of the two preceding explanations. So far as has been observed by placing the larvæ in incubators, the thermal factor seems to be of importance. It is proposed to continue the inquiry, the object being not only to find out whether toxicity is governed by temperature but also how far the relation between the two approximates the formula, $t = f(t)^1$, when t denotes toxicity and t^1, temperature.

The small solubility of HgCl, together with the fact of an exceedingly minute quantity of the salt being necessary to kill the larvæ, offers field for an investigation as to its practical value as a larvicide. The advantage of HgCl lies especially in its being poisonous to the larvæ in doses which cannot have any effect on the human system, so that even drinking water of ponds, etc., can be safely treated with it.

The activities of the larvæ being almost solely connected with the surface of water, all remedial and preventive investigations are reduced to one of finding out a toxic substance which will keep to the surface and not enter into solution, so as to prevent unnecessary expense and the pollution of the entire quantity of water. But such a condition is hard to satisfy, as the substance must at the same time be non-poisonous to human beings and cheaper than the existing larvicides and lasting in effect—a property which should probably be considered its crowning merit.

A large number of experiments was carried out on the relative value of kerosine and HgCl as larvicides. It has been calculated that the cost of 0·001 gm. HgCl would be aproximately equivalent to that of half a minim of the oil; but as even one minim of the oil failed to kill the larvæ, two minims of the oil (equivalent to about four times the cost of HgCl necessary to attain the same result) were used and the results are shown in Graph 6. It will be seen that the immediate effect of the application of the oil was to kill the larvæ almost instantaneously but that it quickly lost in strength through volatilization, whereas the action of HgCl, though slow and unsteady, was generally sure. The transitory nature of the effect of kerosine, however violent its immediate action, imposes severe limitations on its practical value as a larvicide, as it would involve continuous replenishment if any collection of water were to be kept free of mosquitos.* In this respect the superiority of HgCl is evident.

Calomel has two serious drawbacks: firstly, it generally fails to kill the larvæ†; secondly, it would be difficult to keep the salt particles floating for any considerable period.‡ With regard to the first point, the

* Various workers have investigated the nature of the action of kerosine on mosquito larvæ, in the course of which it has been brought out that its action is not of the nature of a simple mechanical interference with their respiration, but that it is chiefly the volatile constituents of the oil that act as poisons.—S. K. Sen, "Observations on respiration of Culicidæ," *Ind. Jour. Med. Res.* 1914; Macfie "The limitations of kerosine as a larvicide, etc.," *Bull Ent. Res.* 1916-17; Freeborn and Atsatt, "The effects of petroleum oil on mosquito larvæ," *Jour. Eco. Ent.*, Concord, 1918.

† From a large number of experiments with various kinds of oils and toxic substances it appears that with those substances which operate by means of their volatile properties, pupæ die earlier than the larvæ, whereas with those which operate through the mouth, larvæ are the first, and in most cases the only ones, to die.

‡ Harris and Meyer, *Berichte*, June 1894.

larvicidal value of the salt would be maintained if it killed the larvæ before they pupated. With regard to the second point, attempts were made to obviate the difficulty in the following ways:—

(1) The salt was administered in exceedingly fine particles by first subliming it; but in practice sublimation cannot be recommended as it has been shown that the salt dissociates in the sublimed condition into Hg and $HgCl_2$.

(2) The salt might be thoroughly shaken with a highly viscous and the least possible volatile material of low specific gravity (such as the "non-drying" oils), and the mixture poured over the water. So far as has been tried, this form of treatment merits attention.

For larvicidal purposes the superiority of HgCl over the other halogen salts of mercury lies in its cheapness whereas its advantage over $HgCl_2$ and HgI_2 2KI lies not only in its insolubility and harmless effect on man, but also in the fact that the two soluble salts are apt to form precipitates with the alkaloidal and other constituents of various kinds of vegetation likely to occur in the breeding places of mosquitos.* Over kerosine its one great advantage is that it is non-flammable.

The larvæ experimented with were those of *S. albopicta.* †

Explanation of graphs.

GRAPH 1. (Plate XXIX).

The figures indicate time in hours.

Crosses indicate when observations were taken.

Each line represents one full-grown *Stegomyia albopicta* larva.

(X) indicates death point.

The point where the line breaks indicates the time when the larva began to show symptoms of sluggishness.

GRAPH 2. (Plate XXIX)

In all the experiments the water had a constant surface-area of 6 inches diameter, the quantity of HgCl used being 0·001 gram.

GRAPH 3. (Plate XXIX).

In all the experiments the water had a constant depth of 10 mm., the quantity of HgCl used being 0·001 gram.

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* The alkaloidal precipitates with $HgCl_2$ have the general composition B. HCl. $HgCl_2$; the alkaloidal precipitates with HgI_2 2KI (Mayer's Reagent) vary in composition.—Henry, *The plant alkaloids*, 1913.

† This paper was read before the Sixth Indian Science Congress, certain alterations and modifications being subsequently introduced.

GRAPH 4. (Plate XXX).

Represents the comparative effects of HgCl and HgCl2.

GRAPH 5. (Plate XXX).

Each line represents the average of three observations.

Crosses indicate death points.

Quantity of water used in each experiment 100 c. c.

Quantity of HgCl, when used, 0·001 gram.

GRAPH 6. (Plate XXX).

Comparative effects of HgCl and Kerosine.

Vertical line represents longevity of larva in hours.

Horizontal line represents time in hours that had passed since the introduction of the larvicide.

Cross indicates death point.

Quantity of Kerosine used, 2 minims, Quantity of HgCl used, 0·001 gram.

The Graph represents the average of three observations.

N. B.—After the 80th hour Kerosine failed to kill.

Did you try these experiments with Anophelines? I understand it is the Mercurous Chloride on the surface film that acts, not the solution. If this is so, a *Stegomyia* larva feeding at the bottom should not show the effects as well as the Anopheline.

I did not experiment with Anophelines. With regard to *Stegomyia*, as the pupæ were generally unaffected, it seemed likely that the salt operated orally and not cutaneously.

I conducted some experiments on the efficacy of Paraformol, the original work on which was done by M. Roubaud at Paris. Paraformol is a solid form of formaline, is finely powdered and distributed on the surface of the water. The Anopheline larvæ devour the powder and are killed in the course of fifteen to thirty minutes. But the pupæ of Anophelines and the larvæ of Culicines are not at all affected.

The powder is insoluble in water, and it either floats on the surface or sinks if it is in bigger particles. There is no likelihood of the powder being taken in by man and even if taken it is not very harmful. If people are particularly scrupulous about it, a filtering of the water through a piece of cloth would get rid of the paraformol. I have tried such water and have found it perfectly harmless and even without smell. A single gram of Paraformol would be enough to spread over several square metres of water surface.

I attempted to keep the salt particle afloat by means of a viscous oil.

If a very viscous oil is used to contain the mercurous chloride the oil will not spread and you would use a great deal, thus enhancing largely the cost.

I could not give this a sufficient trial. I tried coconut oil, and a few other oils. The point is that the expense of a larger quantity is counteracted by its lower volatility.

I cannot understand its efficacy under natural conditions. Paraformol will beat this hollow.

As has been already mentioned in the introductory portion, the results are presented only as an indication of the possibilities of insoluble salts, non-poisonous to human beings. Soluble substances would involve wastage. The activities of the larvæ being mainly connected with the surface area, a substance would be necessary which would keep to the surface without entering into the solution. Under laboratory conditions HgCl, if it can be kept on the surface, will generally remain effective for an indefinite period, being neither soluble nor volatile. In the absence of experiments I cannot claim its present suitability on a field scale. I have already considered, in the latter portion of my paper, the difficulties in the way of keeping the salt particles floating, and mentioned some of the ways in which I attempted to obviate the difficulty.

With regard to Mr. Iyengar's Paraformol, if the water needs filtration it is useless where water supply comes from tanks. A chatty dipped into the tank collects much of the surface water and breaks the film.

What is its specific gravity ? Will it rise if once put down ?

It is heavier than water, but when it is powdered it remains on the surface. Once it goes down it will never come up.

What will be the effect of rain on the film of mercurous chloride ?

I do not know.

Stegomyia larvæ are bottom-feeders; but they die. How do the particles on the surface kill ? It is important to know whether they are killed by particles floating or sunk. *S. albopicta* feeds on solid matter at the bottom and therefore probably does by eating sunken particles. The action of mercury salts is curious. They are very insoluble but have a powerful effect on the human intestines; what happens in the human intestine, nobody knows. Did the larvæ show any symptoms ?

I can only give results and have concluded that probably the salt acts through the mouth. The larvæ became sluggish before they died. *In the graphs I have shown the points when the larvæ began to show* symptoms of sluggishness; these points are indicated by the positions at which the lines break.

To settle the point of oral or other action the intestines of dead larvæ might be tested for mercury.

Did you try shaking up the mercury salt in the water before putting the larvæ in ?

No ; I shook the water violently to dissolve the salt and then filtered it.

It would seem worthwhile to try a parallel series of experiments with mosquito larvæ, in one case simply powdering the salt on the surface film and in the other shaking the water up well so as to get the salt well distributed through it.

24.—OVIPOSITION IN CULICIDÆ

(Plate XXXI-XXXV).

By H. N. Sharma, B.A., *and* S. K. Sen, B.Sc.

This paper deals with the results obtained in one of a series of inquiries on the part played by chemical and physical factors in determining some of the more important activities of insects.

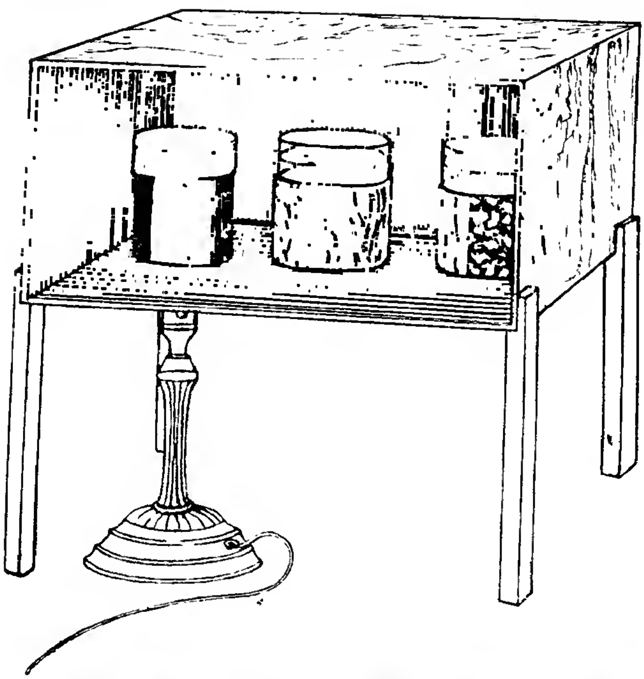
The mosquitos selected for experiment were generally *Culex fatigans*, *Culex vishnui* and *Stegomyia albopicta*, and the object of the inquiry was to ascertain (1) whether choice of water for egg-laying is, in these mosquitos, influenced by the condition of the water as regards temperature, osmotic pressure, and surface-tension, and (2) whether their choice can be influenced by the addition of small quantities of sweet, salt, astringent, or alkaline substances to the water.

The mosquitos were kept in a wooden frame covered with netting and about two feet long, the netting being provided with sleeves for convenience of manipulation. In the cage were two dishes of moist banana for food, and round glass vessels (3 inches diam. × $1\frac{1}{2}$ inches high), containing water or the various solutions for the reception of eggs. In the experiment dealing with the effect of temperature, the arrangement was as shown in Plate XXXI. The lamps were switched off for an hour every day between five and six in the the evening, and fresh ice was provided twice a day at 8 A.M., and 6 P.M. Temperatures were taken at 8 A.M., and generally also at 8 P.M. This rough arrangement was found to give sufficiently constant temperatures for our purpose; the

* The observations recorded in this paper were started at the suggestion of the late Mr. F. M. Howlett, Imperial Pathological Entomologist, the object of the inquiry being explained in the introductory portion which has been taken from the notes left by him. It will be seen that the data obtained exhibited a wide and often unintelligible divergence in the egg-laying propensities in different mosquitos, and, as such, the publication of these results should perhaps have been withheld; but as the observations involved a large amount of arduous work occupying several months, it has been considered desirable that they should be published, even if merely as an indication of the possibilities (or otherwise) of this line of work, rather than be altogether lost to the cause of entomological science. Every effort has been made to condense the results, not only by omitting details but, as will be seen, also by adopting the graphical method of representation; and, as such no particular implication, other than a mere simplified presentation of results, is to be sought in these curves. Where we have attempted to deduce a conclusion, we have done so only on the basis of an average of large numbers of observations, and, even then, we should be far from insisting on its unconditional acceptance.

Except where otherwise stated all remarks relate to *Stegomyia albopicta*.

All the series of experiments enumerated in this paper were initiated by the late Mr. Howlett but no record is available to show what principle underlay the selection of the chemicals experimented with. The First Author was responsible for most of the oviposition figures except the temperature and a few more figures which were obtained by the Second Author who also wrote up the materials and prepared the graphs, and gave what interpretation he considered possible to the selection of the chemicals.



Arrangement of vessels kept inside cage for reception of eggs in experiments regarding oviposition in Culicidæ. From left to right are shown (1) water kept warm by supporting the water-vessel on a black stiff paper roll covering an electric light bulb, (2) water kept at normal temperature, the containing vessel supported on a wooden block ; (3) water kept cool, the containing vessel embedded in a pot of ice and sawdust.

two cool vessels were 1°-3°C below and the two warm ones 5°-7°C above the temperature of the two controls. The temperature of the controls was practically identical with the air-temperature; there was no marked fall at night, owing to the apparatus being in a closed room. The temperature on the roof of the cage was the same in all parts of it.

To test the effect of osmotic pressure, solutions of common salt and sugar were exposed side by side, the object being to eliminate results due to the taste of the solutions. It is not certain how the taste appeals to the mosquito, but there is no doubt that they have at least no objection to sugar solutions of a wide range of concentration.

Solutions of Sodium taurocholate were used in the series designed to test the effect of loosing the surface-tension, but here again there may be complications due to taste-effects. A solution of Saponin was also included in this series; as is well known, it has the effect of greatly increasing the viscosity of water, even when present only in minute quantities.

In the series designed to test the effect of sweet, salt, astringent, and alkaline substances, it was necessary to eliminate the effect of variation in osmotic pressure by using isotonic solutions (M-10).

Each series of observations has been considered in relation to only one physical or chemical factor, but, as has already been stated, one or more additional factors might have operated to make the results what otherwise might have been very different. We shall consider some of the more important possibilities of this kind in the course of our discussion of the results.

It should also be noted that the predilection of mosquitos to oviposit in particular kinds of water has not been considered in relation to a varying atmospheric temperature and moisture. Nor has the fact of unequal illumination of the vessels (placed for the reception of eggs) been taken into consideration in adjudging the mosquitos' liking for any particular substance for oviposition.

In the absence of further experiments it would be hardly profitable to touch on the general question of how far the maternal instinct modifies the phenomenon of oviposition, though the subject would probably repay study, especially in the case of mosquitos, where the fact that they always oviposit in water offers unusual facilities for altering the condition of oviposition, and thereby studying the effects of various substances both on the incubation period of eggs and on the well-being of the offspring. A series of concurrent observations was started in this direction, but the data so far obtained are exceedingly scanty. In our present paper we shall confine ourselves practically only to a consideration of the mosquitos' partiality for any special kind of water for oviposition,

quite independent of any consideration as to how it would affect the future of the offspring.

In the taste experiments (Series 1) (Plate XXXII) the largest number of eggs was laid in 0·6 per cent. NaCl, compared with which those laid in an equimolecular solution of sugar were very few, though in captivity the mosquitos' liking for sugar for drinking purposes is well known. It would appear that the mosquito prefers a salt solution of low strength sometimes even to distilled water (*Culex fatigans* seemed to prefer sugar to NaCl). In judging the results obtained with Ca $(OH)_2$, due consideration must be given to the fact that the substance, when exposed to atmosphere readily forms $CaCo_3$, in which condition it is likely to exert almost a neutral effect. Tannin was tried in order to find out whether the substance, as present in the bark or tissues of trees, imparts any property (*e.g.*, taste or colour) to water occurring in holes trees in which some of mosquitos habitually breed, but they seem positively to dislike it.

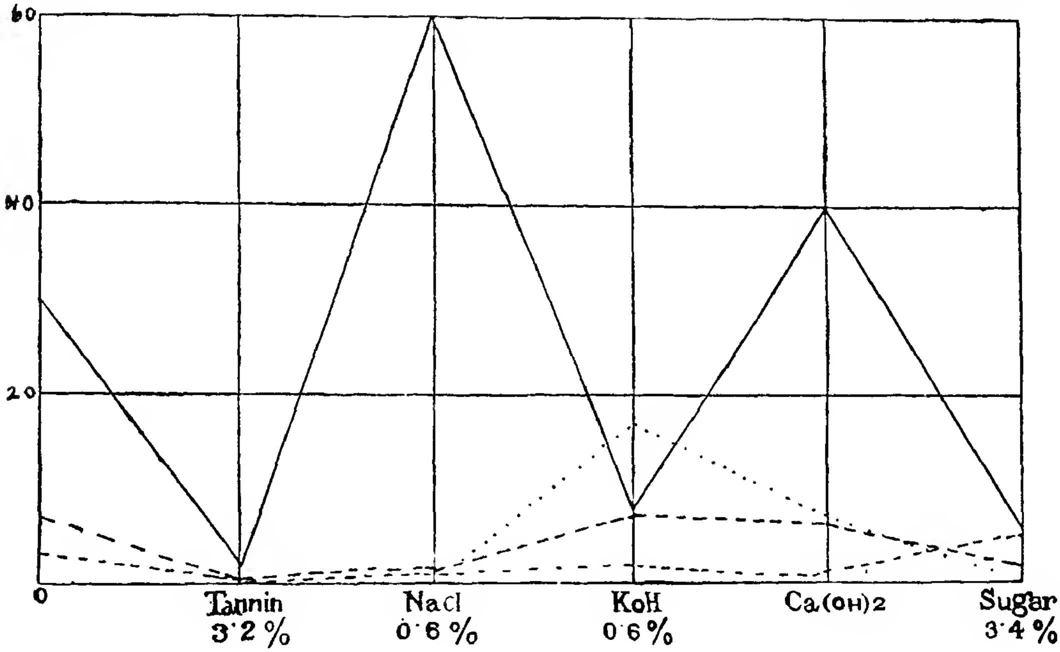
In Series 2 (Plate XXXII) the effects of changing the acid radicle keeping the base (Sodium in this case) constant were studied and the results obtained with equimolecular solutions of these substances are represented in the curves. In the same series are included results obtained with different percentages of NaCl.

Series 2(*a*) (Plate XXXIII) gives figures obtained with varying precentages of NaCl. As will be seen a strength considerably below 1 per cent. is always preferred by them.

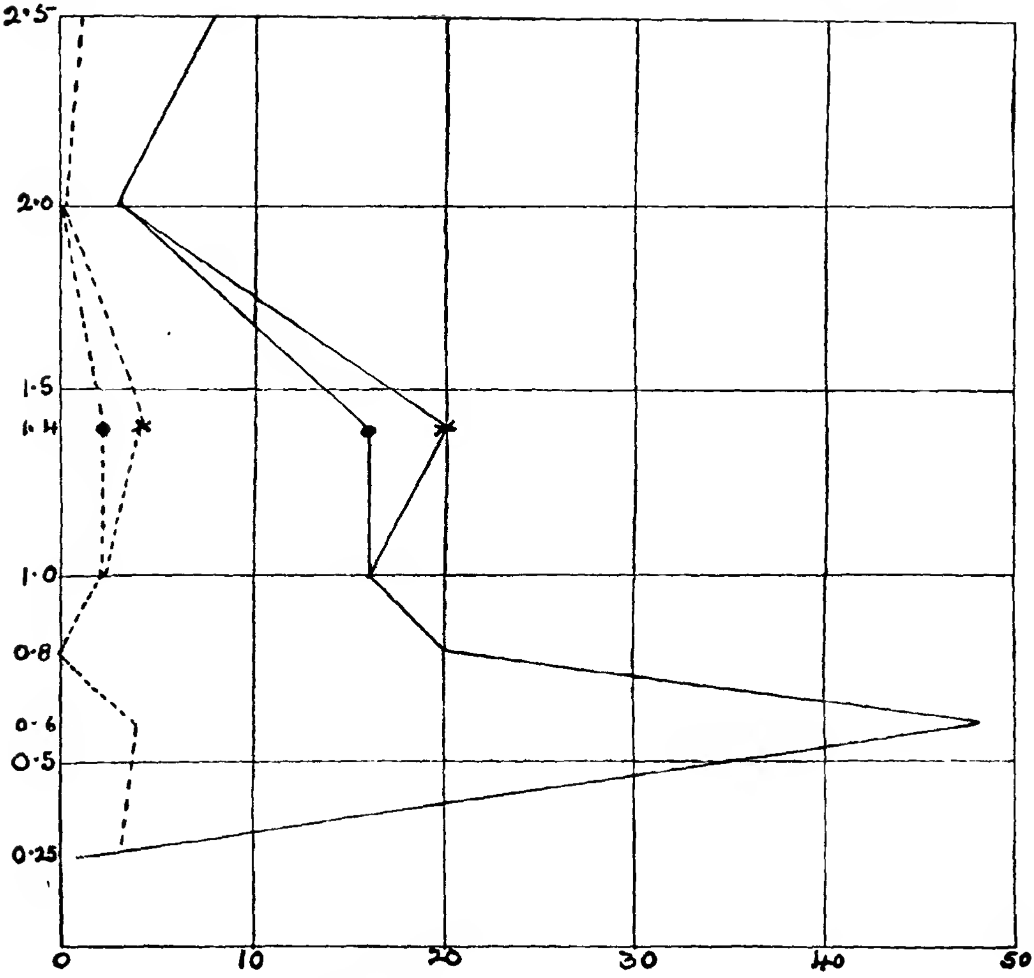
Series 2(*b*) (Plate XXXIII) shows the comparative effects of NaCl and KCl, the results obtained being, as will be seen, very anomalous. It would be useless to seek for an explanation before further experiments are made with different species of mosquitos.

The results obtained with certain organic acids are interesting inasmuch as the salts always appeared better than their corresponding acids, as will be seen in the following statement :—

Chemical.	Number of eggs laid by *Stegomyia albopicta*.	Number of egg-masses laid by *Culex fatigans*.
Citric Acid 0·5 per cent.	9	0
Sodium citrate 0·5 per cent.	1,629	2
Potassium citrate 0·5 per cent.	368	3
Tartaric Acid 0·5 per cent.	93	0
Sodium tartrate 0·5 per cent.	2,367	3
Oxalic acid 0·5 per cent.	14	0
Sodium oxalate 0·5 per cent.	510	0
Water	635	0

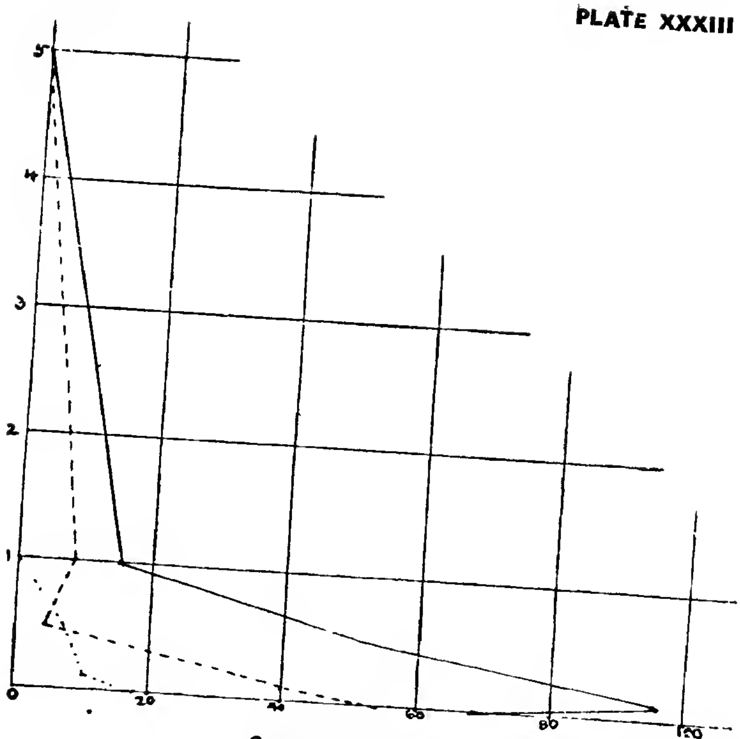


Series 1

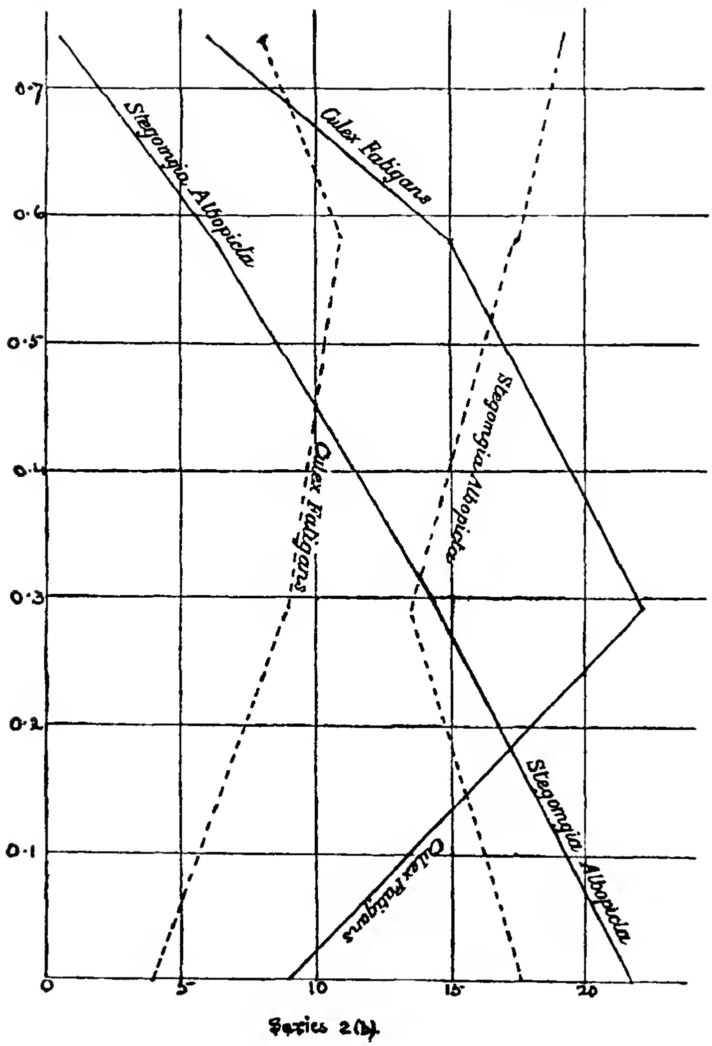


Series 2.

PLATE XXXIII (1



Series 2(a).


0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
5
10
15
20
Stegomgia Albopicta
Culex Fatigans
Culex Fatigans
Stegomgia Albopicta
Stegomgia Albopicta
Culex Fatigans
Series 2(b).

Concurrently with the preceding series of experiments with 0·5 per cent. organic acids another series of observations was made on the effects of certain inorganic acids (against an alkali) the result being as follows :—

Chemical.	Number of eggs laid by *Stegomyia albopicta.*	Number of egg-masses laid by *Culex fatigans.*
H_2SO_4 1 per cent.	60	0
0·5 per cent.	11	0
HCL. 1 per cent.	31	0
0·5 per cent.	89	0
Boric Acid (? 0·5 per cent.)	935	2
H_2O	1,459	2

Series 5 (Plate XXXIV) shows the comparative effects of certain well-known disinfectants and therefore the practical value of these figures is obvious. The inclusion of Malachite green was suggested by its colour which could be conveniently tried against the red of $KMnO_4$. As was expected, mosquitos showed a distinct preference for green over red, but it is interesting to note that they preferred the lower of the two intensities. In connection with the figures obtained with $HgCl_2$ it may be noted that in another paper by one of the present writers it has been shown that 0·001 per cent. $HgCl_2$ has hardly any deleterious effect on mosquito larvæ,* and as such, the fact that they oviposited in corrosive sublimate does not conclusively prove their indifference to a poisonous substance during oviposition.

Series 6 (Plate XXXIV) represents results obtained with certain vegetable products. Mannite is the sweetish crystalline compound occurring in celery, sea-grasses, etc., and asparagin occurs in asparagus. As will be noticed the subtsances have been selected, to some extent, with reference to their position in the system of organic compounds, the citrate and the bitartrate being both oxidation products of glycols, and asparagin being the amide of aspartic acid, which on treatment with nitrous acid produces malic acid, another oxidation product of glycol. The partiality shown to Sodium citrate even in preference to water is borne out by the observations recorded in a previous series. But the figures obtained with 0·5 per cent. NaCl are unexpectedly meagre.

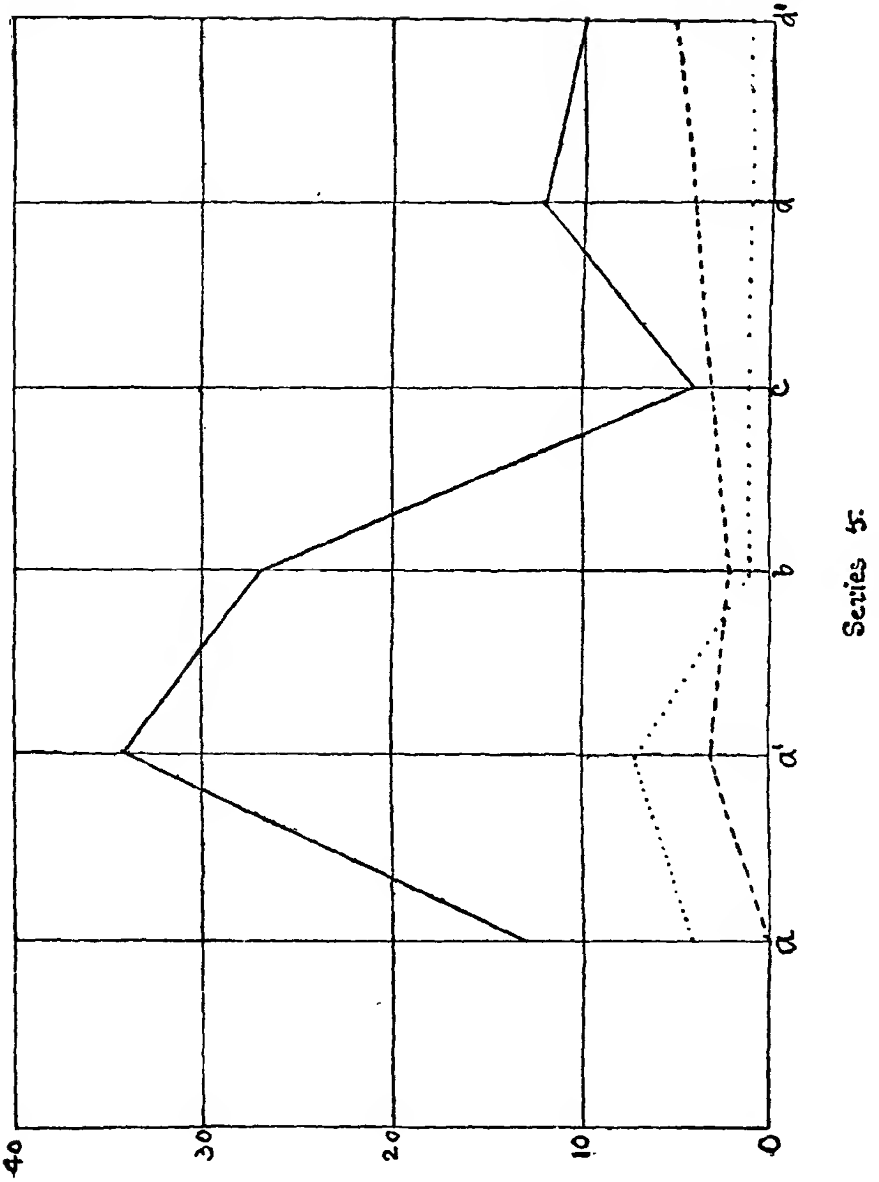
* A note on the effects of Mercurous Chloride on Culicid larvæ, by S. K. Sen.

With regard to the results obtained by an alteration in the surface-tension (Series 7) (Plate XXXV), an addition of NaCl was made in two cases in order to stimulate oviposition, it having been previously found that, generally speaking, mosquitos readily oviposit in a salt solution of low strength, sometimes in preference even to distilled water [*e.g.*, in series 2(*a*)]. As will be seen Sodium taurocholate appeared to be distinctly better than Saponin and even than distilled water.

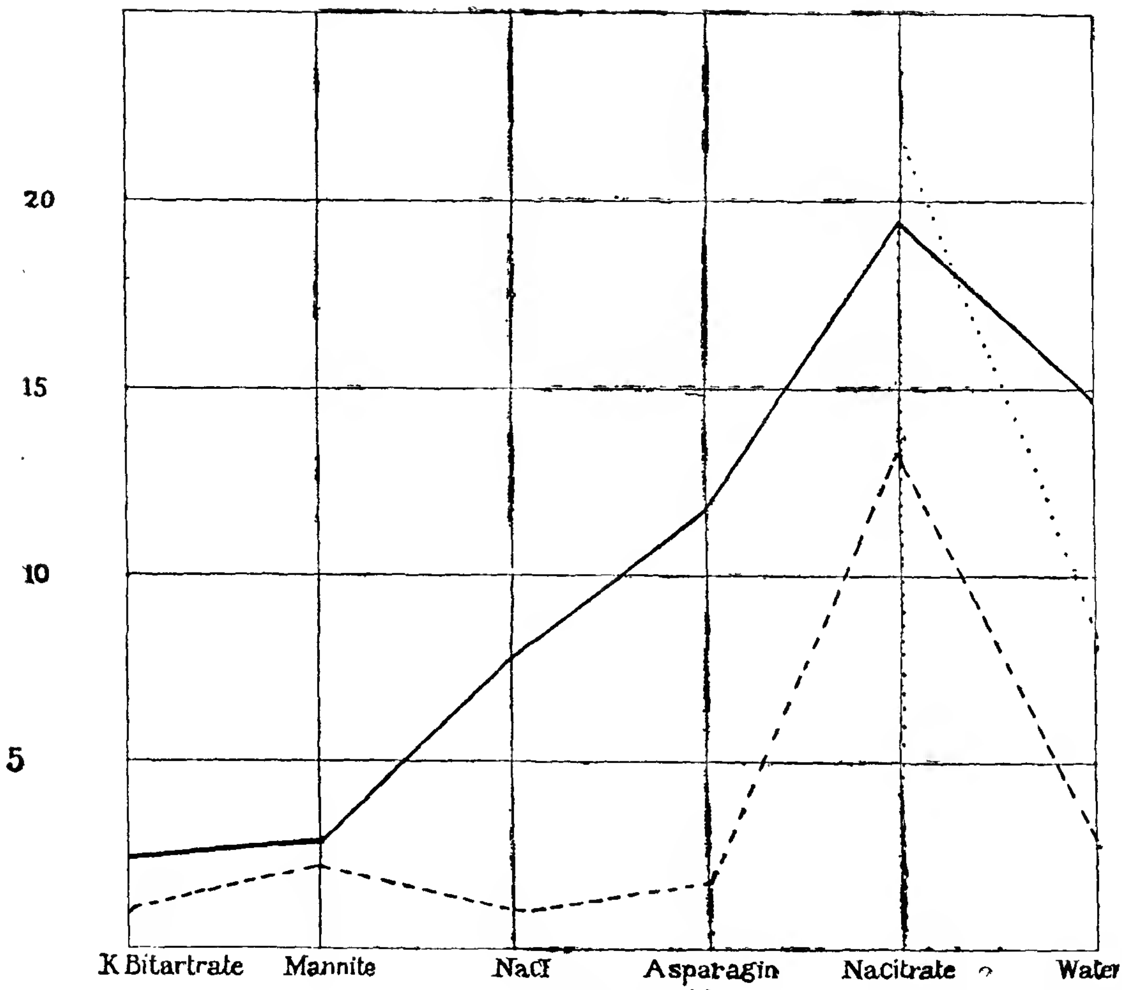
With regard to the results obtained in a varying temperature (Series 8) (Plate XXXV) it is open to question how far they have been correctly represented in the curves, if it is assumed that the act of oviposition is more or less dependent on a differential thermal stimulus, as generally no three temperatures remained constant for more than a day. It would appear, however, that in a temperature variable between 23° and 35°C, almost all the species of mosquitos experimented with (the notable exception being *Anopheles rossi*) preferred the hottest of the three temperatures, the results being summarized in the following statement :—

Mosquito.	Number of eggs or egg-masses laid in water.		
	Hot.	Normal.	Cold.
Culex fatigans	31	14	2
„ *vishnui*	19	2	2
„ *gelidus*	3	0	0
? *Culex* sp. (yellow)	10	1	0
Stegomyia albopicta	1,381	415	393
„ *sugens*	33	60	0
Armigeres obturbans	50	0	0
Anopheles rossii	108	393	0
Culex concolor	2	0	2

The oviposition results recorded in this paper may be correlated with the observations made by one of the present writers on the effects of certain of these substances on the development of the young stages of *Culex fatigans*.* But in doing so it should be remembered that as the layings in the case of *Culex fatigans* were exceedingly few, the correlation of the two sets of observations is likely to leave a large margin of error



40
30
20
10
0
a
a'
b
c
d
d'
Series 5



(All 0.5%)

Series 6

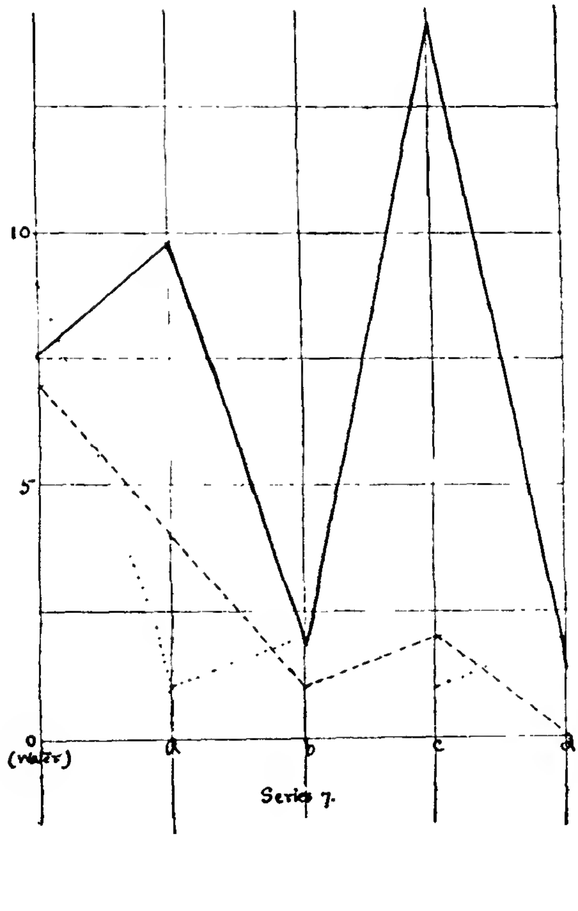
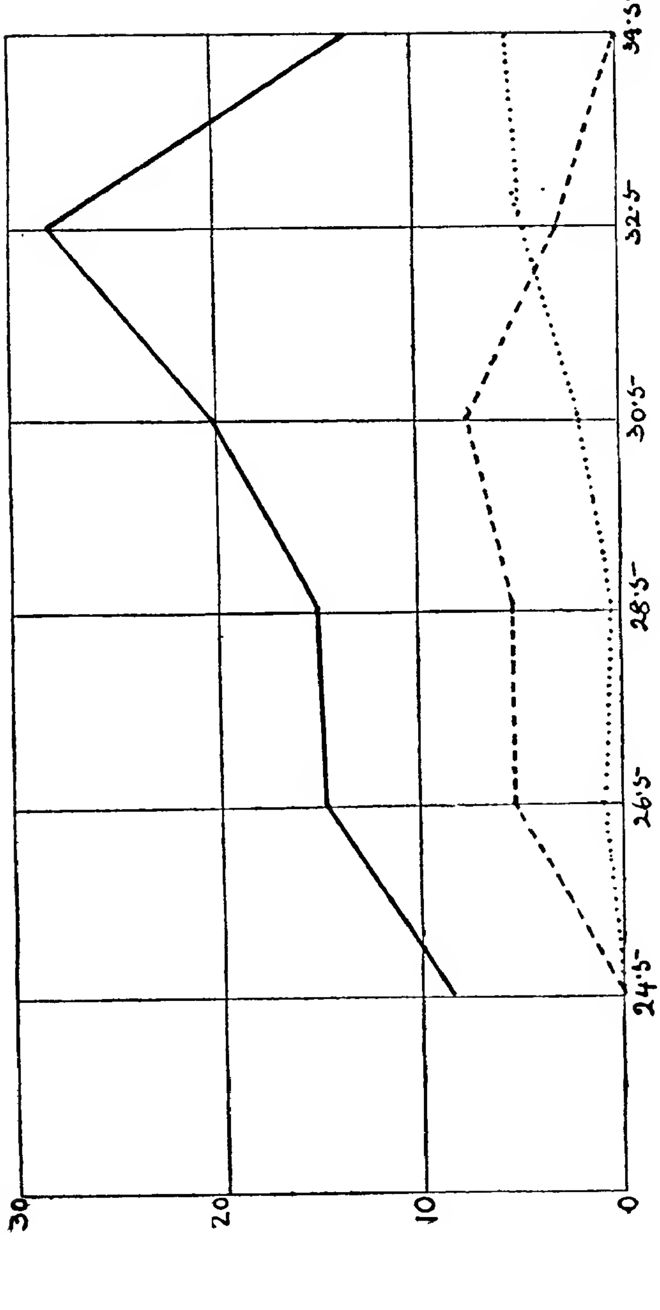

10
5
0
(water)
a
b
c
d
Series 7.

PLATE XXXV (2)



Series 8.

in our views with regard to the maternal instinct obtaining in this species of mosquito.

* " A preliminary note on the action of acids, salts and alkalies on the development of Culicid eggs and larvæ," by H. N. Sharma, B.A.

Explanation of Graphs.

SERIES 1.

Stegomyia albopicta ————————

Culex fatigans - - - - - - - - - -

Anopheles rossii . . . .

(?) Culex sp. — — — — — —

The vertical line represents tho number of eggs or egg-masses laid. In the case of *Stegomyia albopicta* one-tenth of the actual number of eggs laid is represented.

SERIES 2.

Stegomyia albopicta ————————

Culex fatigans - - - - - - - - - -

The horizontal line represents the number of eggs or egg-masses laid. The vertical line represents percentages of the sodium salts used, which are :—

NaCl, 0·25, 0·6, 1, 2 ; $NaNo_3$ 0·8 ; Na_3No_4, 1·4 ;

Na_2So_4, 1·4 ; $Na_2S_2O_4$, 2·5.

Against the percentage of 1·4, Na_3Po_4 is indicated by Na_2So_4 is indicated by ×

In the case of *Stegomyia albopicta* one-tenth of the actual number of eggs laid is represented

SERIES 2(*a*).

Stegomyia albopicta ————————

Culex fatigans - - - - - - - - -

Anopheles rossii — — — — — — —

The horizontal line represents the number of eggs or egg-masses laid. The vertical line represents the percentages of NaCl.

In the cases of *Stegomyia albopicta* and *Anopheles rossii* one-tenth of the actual number of eggs laid is represented.

SERIES 2(*b*).

Stegomyia albopicta } ————(NaCl) ; - - - - -(KCl) .
Culex fatigans }

The horizontal line represents the number of eggs or egg-masses laid. The vertical line represents the percentages of the salt, which are 0·29, 0·58 and 0·74 (together with a control).

In the case of *Stegomyia albopicta* one-tenth of the actual number of eggs laid is represented.

SERIES 5.

a, indicates malachite green (0·001 per cent.);
a', Malachite green (0·0001 per cent.);
b, $KMnO_4$ (0·001 per cent.);
c, $HgCl_2$ (0·001 per cent.); *d*, Salicylic acid (0·1 per cent.); and
d, Salicylic acid (0·001 per cent.).
The vertical line represents the number of eggs or egg-masses laid.
Stegomyia albopicta ————————
Culex fatigans — — — — — —
(?) Culex sp. . . . .
In the case of *S. albopicta* percentages of the total number of eggs laid are represented.

SERIES 6.

Stegomyia albopicta ————————
Culex fatigans — — — — — — —
Anopheles culicifacies . . . .
The vertical line represents the number of eggs or egg-masses laid. In all cases one-tenth of the actual number of eggs or egg-masses laid is represented.

SERIES 7.

Stegomyia albopicta ————————
Culex fatigans — — — — — — —
(?) *Culex* sp. . . . .
a represents sodium taurocholate (0·05 per cent.).
b saponin (0·07 per cent.)
c NaCl (1 per cent.) + Sodium taurocholate (0·05 per cent.)
d NaCl (1 per cent.) + saponin (0·07 per cent.)
The vertical line represents the total number of eggs or egg-masses laid. In the case of *Stegomyia albopicta* one-hundredth of the actual number of eggs laid is represented.

SERIES 8.

Stegomyia albopicta ————————
Culex fatigans — — — — — — —
Culex vishnui . . . .
The horizontal line represents temperatures in centigrade. The vertical line represents the number of eggs or egg-masses laid
The series represents the average of two consecutive temperatures.
In the case of *Stegomyia albopicta* one-tenth of the actual number of eggs laid is represented.

25.—A PRELIMINARY NOTE ON THE ACTION OF ACIDS, SALTS AND ALKALIES ON THE DEVELOPMENT OF CULICID EGGS AND LARVÆ.

(Plate XXXVI).

By H. N. Sharma, B.A.

The experiments referred in this paper were made with the object of determining the effect of various chemicals on the eggs and larvæ of mosquitos, the immediate purpose being to gain such insight as would lead to more precise series of experiments with more definite compounds. While I was investigating the effects of different chemicals upon the oviposition of mosquitos, the results obtained prompted me to undertake the present series of experiments with all the early stages of Culicidæ.

It occurred to me that attempts might be made to ascertain whether there was any connection between the oviposition and the development of eggs and larvæ of Culicidæ with various chemicals.

The chemicals employed are :—

Acids: Tannic, Salicylic, Boric, Malic, Butyric, Acetic, Lactic, Tartaric, Oxalic, Sulphuric and Hydro-chloric.

Salts: Mercuric chloride, Potassium permanganate, Sodium nitrate Sodium chloride, Potassium chloride, Sodium phosphate, Sodium sulphate, Sodium thiosulphate, Potassium bitartrate, Sodium tartrate, Sodium citrate, Potassium citrate and Sodium oxalate.

Alkalies: Sodium hydroxide, Potassium hydroxide and Calcium hydroxide.

As regards the selection of substances, some were taken up with reference to their occurrence in natural breeding places, while others had reference to their larvicidal properties. The quantities were taken not at random but in the majority of cases in definite proportions of their molecular weights; in others in quantities that seemed requisite after prolonged experience. For our present purpose it would be unnecessary to discuss the principles underlying these selections. The object of this paper is simply to present in a brief form a few interesting facts with regard to the behaviour of these substances towards the eggs and larvæ of mosquitos.

The experiments with Sodium chloride had reference to the practical value of treatment of breeding places of mosquitos with common salt

and to the possibility of their breeding in naturally saline water. The results obtained with varying percentages of Sodium chloride are shown in the accompanying graph. (Plate XXXVI).

About 4 dozen glass dishes of almost the same capacity were selected for experiments. In these dishes measured quantities of various solutions of different strengths were kept and the original strength was maintained by adding the necessary amount of distilled water after every 24 hours, to make up the deficiency caused by evaporation. Pure water was used as a control.

The eggs employed in the experiment were those of *Culex fatigans*, because it is the most common domestic mosquito and also for the reason that it breeds almost freely even in very low temperatures, as these experiments were performed in the winter season. In the course of the experiment a stage arrived, when it appeared that the larvæ in various solutions in which they had hatched, were suffering in development owing to lack of food. 0·001 per cent. Sanatogen was therefore added in each dish. This addition of Sanatogen gave a sort of stimulus to all the larvæ. Still owing to the low atmospheric temperature prevailing at the time (being winter) the development was exceedingly slow.

In some chemicals the eggs did not hatch at all, in some the eggs did not develop but split up; while in some the larvæ died while just in the act of emergence; in some the larvæ half emerged and died before complete emergence; in some the larvæ met instantaneous death immediately after emergence; in some the larvæ prospered for some time but died before attaining full maturity; and in the rest they attained maturity and mosquitos emerged.

In determining the susceptibility of the eggs and larvæ to various chemicals the results fall under 6 heads:—

Series A. (Life cycle incomplete)—

(1) Eggs did not hatch.

(2) Larvæ partially hatched and died.

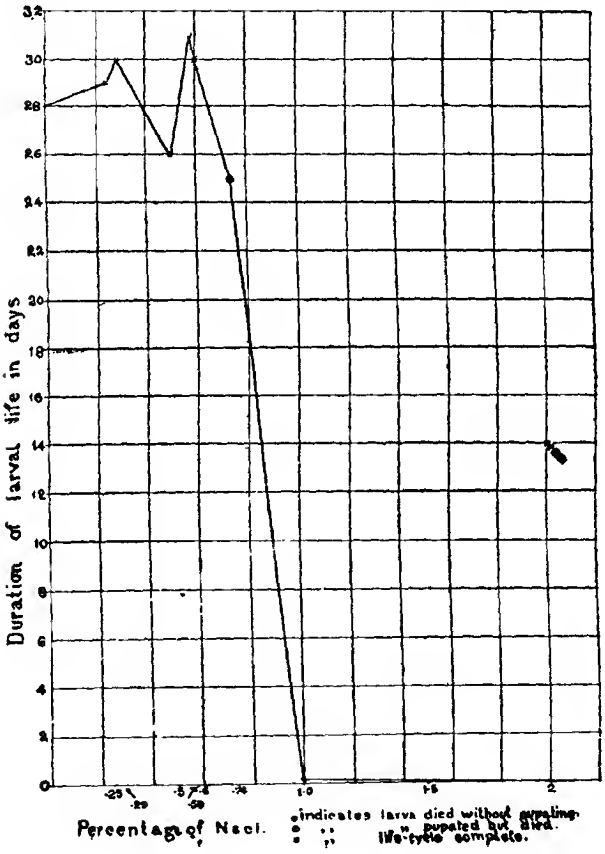
(3) Larvæ hatched and died instantaneously.

(4) Larvæ hatched and died in less than 24 hours.

(5) Larvæ hatched, survived from 1 to 25 days without attaining maturity.

Series B :—

(6) Life cycle complete.


Duration of larval life in days
Percentage of Nacl.
indicates larva died without pupating.
" " pupated but died.
" " life-cycle complete.

Series A.

1. Eggs did not hatch in the following chemicals :—

Substance.	Percentage.	Remarks.
Salicylic acid	0·1	Eggs split up.
Oxalic acid	0·5	
Caustic potash	1·0	Partially hatched in one expt. but larvæ died before emergence.
Ditto	0·6	
Ditto	0·5	
Citric acid	0·5	Hatched in one instance out of 3 expts., but the young larvæ died in less than 12 hours.
Sulphuric acid	1·0	

2. Larvæ partially hatched and died.

Tannin	3·2	
Caustic potash	0·6	
Potassium permanganate	0·001	
Sodium oxalate	0·5	

In the effects of the above solutions employed in No. 1 and 2 experiments there is not much difference, I have found that if sufficiently developed eggs are used in expt. No. 2. they hatch partially, but if fresh eggs are employed, they give the same result as in expt. No 1 ; that is, they do not hatch.

3. Larvæ hatched but died instantaneously.

Butyric acid	0·5	
Acetic acid	0·5	
Hydrochloric acid	0·36	
Ditto	0.18	
Lactic acid	0·5	

4. Larvæ hatched and died in less than 24 hours.

Sodium chloride	2·0	
Ditto	1·0	
Sodium phosphate	1·4	
Sodium sulphate	1·4	
Sodium thio sulphate	2·5	
Sodium nitrate	3·8	
Potassium bitartrate	0·5	
Mercuric chloride	0·001	
Caustic soda	1·0	
Tartaric acid	0·5	
Malic acid	0·5	
Sulphuric acid	0·5	
Boric acid	2·5	
Ditto	0·5	
Citric acid	0·5	In 2 cases they did not hatch but in the 3rd case the larvæ hatched and died.

5. Larvæ hatched but did not attain complete maturity.

Substance.	Per cent.	Larvæ died after the following number of days after hatching.
Caustic potash	0·25	1
Potassium chloride	0·58	7
Ditto	0·74	6
Sodium chloride	0·74	24

As regards Sodium chloride 0·74 per cent. out of 57 larvæ, originally hatched, only 2 survived up to 23rd day. Out of these one died on the 24th day and the remaining one pupated and died on the 25th day.

Series B.

6. Life cycle complete.

Substance.	Per cent.	Egg period in days.	Larval period in days.	Pupal period in days.	Total.	Remarks.
Salicylic acid . . .	·001	3	28	3	34	
Sodium chloride . . .	0 6	3	30	3	36	
Ditto . . .	0·58	3	31	3	37	
Ditto . . .	0·5	3	26	3	32	
Ditto . . .	0·29	3	30	3	36	
Ditto . . .	0·25	3	29	3	35	
Sodium tartrate . . .	0·5	3	22	2	27	Larvæ attained maturity in the shortest period.
Sodium citrate . . .	0·5	3	29	3	35	
Potassium citrate . .	0·5	3	28	3	34	
Potassium chloride . .	0·5	3	33	3	39	Took greater period.
Calcium hydroxide . .	..	3	29	3	35	
Water	..	3	28	3	34	Average.

In Series B as the table shows the quickest larval development took place in Sodium tartrate 0·5 per cent., the slowest development in Potassium chloride and the average development in water, Potassium citrate 0·5 per cent. and Salicylic acid 0·001 per cent.

The most interesting and important fact is that the list of substances in which either the eggs did not hatch or the larvæ died soon after hatch-

ing, includes some of the chemicals in which the least number of eggs were laid.* They are :—

Acids : Citric, Oxalic, Malic, Lactic, Sulphuric and Hydrochloric.

Alkalies : Caustic potash and Caustic soda. The substance in which the larvæ and pupæ developed most quickly is also the same in which the largest number of eggs were laid, *i.e.*, *Sodium tartrate.*

One remarkable fact about Sodium tartrate is that the larvæ developed very fairly in the beginning of the experiment and nearly achieved maturity, one week after their hatching. But after that their progress was at a stand-still for about 10 days and they did not pupate until some food in the form of sanatogen (as referred to in the beginning) was added. Another striking fact is that it was also in the first week of their larval stage, that the number came down from 98 to 7 only, all of which pupated afterwards. Of course the mortality was high in the beginning of the larval stage in all these solutions, but not to such an extent.

So far as I have tried, Sodium tartrate seemed to be very well adapted to hastening the development of mosquito larvæ.

Results obtained with Sodium chloride :—

Per cent.	Result.
2·0	Larvæ hatched and died immediately.
1·0	Larvæ hatched and died within 24 hours.
0·74	Larvæ hatched but out of 57 only 2 were alive on the 18th day ; 1 more died on the 23rd day and the remaining one pupated and died on the 25th day.
0·6	Life cycle complete.
0·58	Ditto.
0·5	Ditto.
0·29	Ditto.
0·25	Ditto.

Results obtained with Potassium chloride :—

Per cent.	Results.
0·74	Larvæ hatched but died within 8 days.
0·58	Larvæ hatched but died within 9 days.
0·29	Larvæ hatched, pupated and mosquitos emerged.

* *Vide* " Oviposition in Culicidæ " by Mr. S. K. Sen and H. N. Sharma presented with this paper to the Meeting.

Results obtained with Caustic Potash.

Per cent.	Results.
1·0	Eggs did not hatch.
0·6	Eggs did not hatch. (In one experiment hatched partially but all larvæ died before complete emergence).
0·5	Eggs did not hatch.
0·25	Eggs hatched but all larvæ died within 48 hours

By looking at the table No. 4 it would appear that in 1·0 per cent. Caustic soda the eggs hatched but the larvæ died within 24 hours but in the case of Caustic potash eggs did not hatch at all in 1·0 per cent., 0·6 per cent. and 0·5 per cent. This shows that the toxicity of Potassium hydroxide is far greater than that of Sodium hydroxide of the same strength.

In conclusion, the preliminary character of my experiments may again be emphasized. Final conclusions can not be drawn, at least with any degree of satisfaction from laboratory experiments alone. These should obviously be followed by field experiments under natural conditions.

The general results are intended to give some clue as to possible lines upon which this investigation may profitably be pursued.

In this respect I have noticed an interesting point. When bamboos are cut the juice exudes into the contained rain water and the result is a fermenting mass containing alcohol. This is very suitable for the development of *Leicesteria* larvæ. Did you try alcohol ?

No.

26.—THE DISTRIBUTION OF MOSQUITOS IN RELATION TO THE ZOOGEOGRAPHICAL AREAS OF THE INDIAN EMPIRE.

(Plate XXXVII).

By Major S. R. Christophers, C.I.E., I.M.S., *Central Malaria Bureau, Kasauli.*

In 1916 I published a " revision " of the Indian Anophelinæ in which I gave, under the different species, the various areas from which up to that date they had been recorded, whether in published works or the collection at the Central Malaria Bureau. It seems desirable however to supplement this information with such further facts as have been gathered and to put it in a form which will make the zoogeographical distribution of this group more easily appreciated.

Regarding other mosquitos than Anophelines only very few tentative *data* regarding their distribution can as yet be given, partly because they are less thoroughly collected than are Anophelines and partly owing to difficulties of synonomy which as regards the Anophelines have now largely disappeared.

The Anophelines form a very suitable group for a basis in the study of the geographical distribution of the Culicidæ both because they have been very thoroughly collected and because much work has been done in regard to the affinities of the species. Also the areas of distribution of these species are of a very suitable size, neither too large nor too small to be instructive. Among Anophelines there is at present recognised only one genus. In the case of the Culicidæ there are many and the divergence of forms is obviously much greater. We might think *a priori* therefore that in the Anophelines we have, at least in part, to study a relatively more recent diffusion. As we shall see it is necessary to recognise caution where, as is evidently the case, the distribution of individual species is often but a part of general faunal changes.

As is well known the surface of the earth has, on a zoogeographical basis, been divided into certain faunistic provinces and regions. For reasons I need not enter upon here these have largely been based upon the distribution of mammals, to a less extent on that of birds and reptiles and much less closely, if in some cases at all, upon lower forms of life including the Insecta.

As regards India, Blanford (1), who is the chief authority on the Indian faunal areas, in one of his earlier papers divides the Indian Empire into four main areas :—

(I) The Punjab, including Sind, the desert country east of the Indus, Cutch and Western Rajputana.

(2) The Indian Province proper, including all India east of Delhi and Kathiawar to the Rajmahal hills and the whole of the Peninsula south of the Ganges, with the exception of the western coast and including north Ceylon.
(3) The Eastern Bengal Province, including areas east of Calcutta.
(4) Malabar and South Ceylon.

In a later paper Blanford (2) divides India into 19 sub-areas grouped under five main provinces, (1) the Indo-gangetic plain, (2) the Peninsula, (3) Ceylon, (4) the Himalayan area and (5) Assam, Burma and East of Bengal. The Peninsular area includes 5 of the sub-areas, namely (*a*) Rajputana and Central India, (*b*) the Deccan tract, (*c*) Bihar and Orissa tract, (*d*) the Carnatic or Madras and (*e*) the Malabar Coast. The limits of these areas and sub-areas is given in Map 1 (Plate XXXVII).

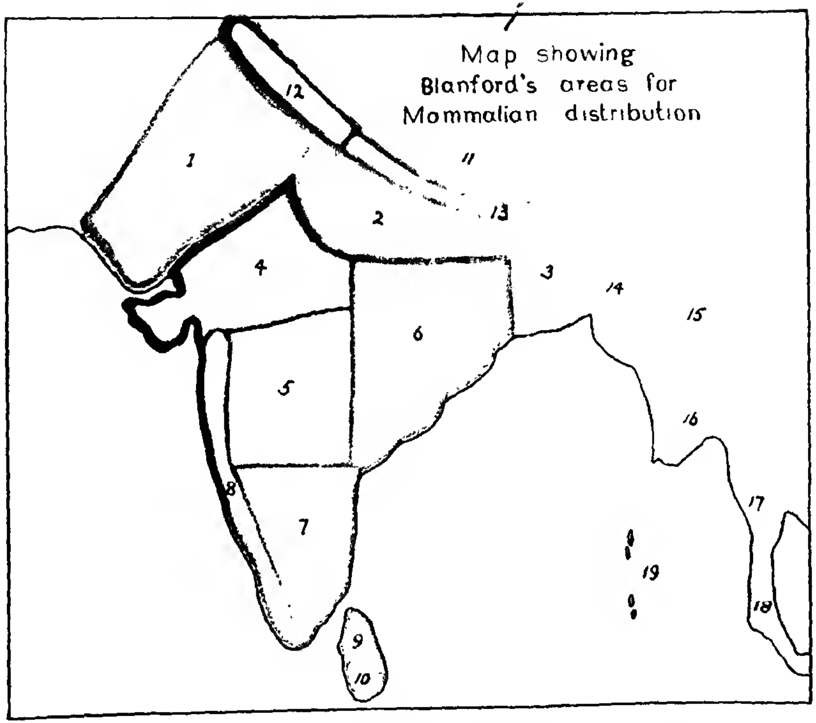
In regard to these areas the Punjab tract is considered to be Holarctic, the remaining tracts Oriental. The most important feature would seem to be the occurrence of a strong Malayan facies in those parts east of Calcutta and in the isolated Malabar tract which includes also Southern Ceylon. There is also some extension of Malayan affinities to the Himalayan area particularly in the eastern Himalayan tract. A peculiar area is called attention to in Southern India which is characterised chiefly by lower vertebrate forms and is termed "Dravidian."

So far for the distribution of mammals. Considering the distribution of Anopheles, at first quite independently of these results, it is obvious that certain quite definite distributional sub-divisional areas exist in India in relation to this group. To give precise limits to these areas is often difficult but we may distinguish at least the following :—

(1) The Indo-Gangetic area, characterized by the presence of

A. culicifacies, Giles.
A. rossii, Giles.
A. fuliginosus, Giles.
A. stephensii, Liston.
A. sinensis, Wied.
A. barbirostris, Van der Wulp.

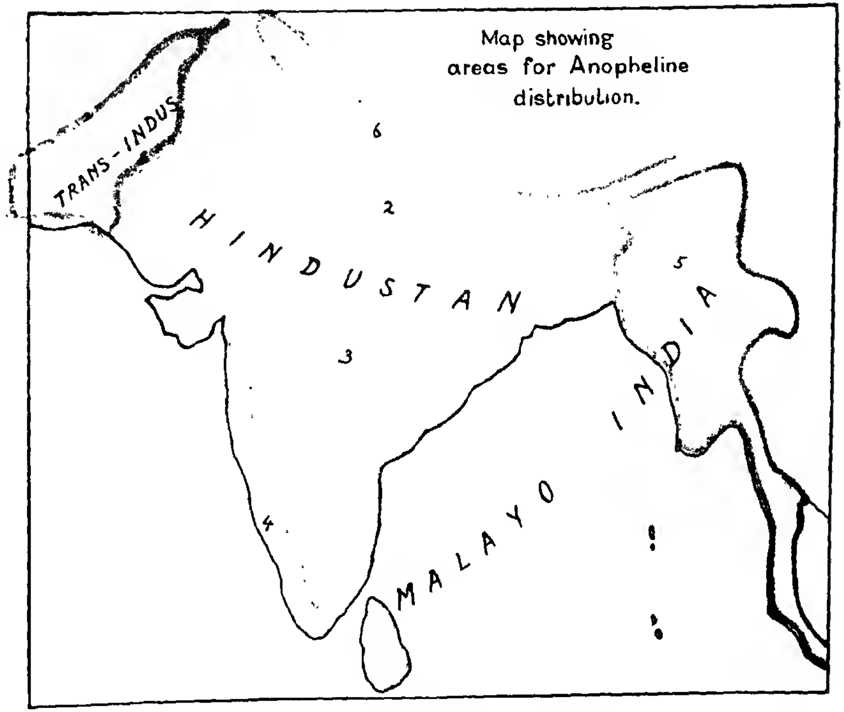
(2) The Trans-Indus area.—Whilst this area has a rich anopheline fauna representative of the Indo-gangetic area as well of the Himalayan area to be considered later, it is strikingly distinct in the possession of species which are found nowhere else in India. This character applies also to the Culicidæ other than Anopheles, so that whilst this area might be considered part of the Indo-gangetic area I think it is more useful to treat it as distinct. Two species of Anopheles which are common to it, *A. superpictus* and *A. rhodesiensis*, are found here



Map I. *Blanford's areas for Mammalian distribution.*

Yellow, Indo-Gangetic area; blue, Peninsular and Ceylon areas; red, Eastern Bengal and Himalayan areas.

1, Punjab; 2, North-Western Provinces; 3, Bengal tract; 4, Rajputana and Central India; 5, Deccan; 6, Bihar and Orissa; 7, Carnatic or Madras; 8, Malabar; 9, North Ceylon; 10, South Ceylon; 11, Tibet; 12, Western Himalaya; 13, Eastern Himalaya; 14, Assam; 15, Upper Burma; 16, Pegu; 17, Tenasserim; 18, South Tenasserim; 19, Andamans and Nicobars.



Map 2. *Areas for Anopheline distribution.*

1, Trans-Indus area; 2, Indo-Gangetic area;

3, Peninsular area; 4, Malabar and Ceylon;

5, Assam and Burma; 6, Himalayan area.

and nowhere else in India. Two other species, *A. pulcherrimus* and *A. turkhudi*, though their distribution extends beyond the Trans-Indus tract, are more abundant here than elsewhere and are species whose main distributional area lies to the West of India. *A. superpictus* occurs in a belt stretching from North Africa and South Europe through the Caspian area and Turkestan to the Quetta hills. *A. turkhudi* has a distribution which I have described as Saharan. It occurs in North-Western India and the Deccan, being unknown in the east. *A. pulcherrimus* is the dominant anopheline of Mesopotamia and of the plains of the Oxus. Its Indian home is the Indus plain though it occurs sparingly as far as the United Provinces. *A. rhodesiensis* is an African species common in Arabia. Any collection of mosquitos from the Trans-Indus is generally easily to be located by these and other features.

(3) The Malabar area. This region is a very conspicuous one. From somewhere north of Bombay down the South-Western Coast is encountered a complexus of species in striking contrast to that of the Indo-gangetic area. Characteristic of the area is the common occurrence of *A. jamesii*, *A. karwari*, *A. punctulata*, *A. aitkeni*, and *A. jeyporiensis*. In this area is found the tree-breeding species, *A. culiciformis*, Cogill, unrecorded elsewhere.

(4) The Peninsular area. Regarding this area we require far more detailed information. For the present we may treat of it as a single area though it is clearly to a certain degree composite. On the west it merges gradually into the Malabar area and its common species are largely those of the Indo-gangetic area. On the coast are conditions suggestive of the Assam and Burmese areas, *e.g.*, the occurrence of *A. minimus*, *A. vagus*, *A. leucosphyrus* and *A. ludlowi*.

Regarding Ceylon there is so far no evidence of a particularly distinct anopheline fauna and for the time it may be best I think regarded as included in the Malabar area. From it have been recorded :—

A. rossii, Giles.	*A. fuliginosus*, Giles.	*A. minimus*, Theo.
A. vagus, Don.	*A. maculatus*, Theo.	*A. asiatica*, Leic.
A. ludlowi, Theo.	*A. karwari*, James.	*A. sinensis*, Wied.
A. tesselatus, Theo.	*A. culicifacies*, Giles.	*A. peditæniatus*, Leic.
A. jamesii, Theo.	*A. listoni*, Liston.	*A. barbirostris*, V. d. W.

(5) The Assam-Burma area. From about east of Calcutta the Indo-Gangetic fauna shows a marked change approximating to that already noted for the Malabar area. In addition to *A. rossii*, Giles, of more westerly regions, occurs also the eastern *A. vagus*, Don. There is also an eastern species so far unrecorded from other parts of India, *viz.*, *A. kochi*, Don., very characteristic of the Malayan fauna further east.

(6) Of great interest is the Himalayan area. The characteristic species are *A. gigas* and *A. lindesayi*. Perhaps the most interesting

feature of this fauna is that it is not restricted to the Himalayas but occurs as outliers far to the south in Tropical India, a point I shall return to later.

Broadly speaking, after excluding the fringes of what are clearly western faunas and practically influence only the Trans-Indus area we can distinguish in the Indian Empire two types of Anopheline fauna.

To the first we can assign the Indo-gangetic tract, the Deccan and to some extent the Peninsular area generally.

To the second we must assign the countries east of Calcutta and the Malabar tract with Ceylon and possibly to some extent the coastal and hill areas of the Madras tract.

Examining the essential nature of the difference in these types of fauna one is struck by the fact that it is chiefly in the degree of absence of Malayan forms that these differ. It would appear legitimate to say that the Indian area is characterized by an impoverished Malayan Anopheline fauna, this impoverishment reaching to a high degree in the first series of tracts and being but little marked in the second. There is on the whole a far greater change beyond the western frontier than to the east. This will be seen from the following abstract of species :—

African species.	Common to Africa and India (Ex. Trans-Indus).	Indian species (Ex. Trans-Indus).	Common to Malay and India.	Malay species.
45	4	32	21	32

As Major Gill, I.M.S., once aptly put it to me, there is something like a mosquito fault at about the Indus.

Though few in number there appear to be quite definitely some Indian species whose zoocentre is included in the Indian Empire and which help to make good the impoverishment of Malayan forms in a large part of the area. These species often have a westerly focus or tendency of occurrence. One may mention *A. stephensii* unrecorded in Malay and stretching to the confines of the Arabian Desert; *A. culicifacies*, a dominant Indian form not recorded from Malay but occurring as far at least westward as Arabia and Palestine. More strictly Indian still appear to be the species *A. theobaldi*, *A. willmori* and *A. fowleri*. Also the species *A. listoni* may not be quite identical with the African *A. funestus*. *A. jeyporiensis* is also a species not recorded from Malay though one would have expected its occurrence in this region.

I propose in view of these facts to speak, with reference to anopheline distribution, of two areas in India (1) Hindustan and (2) Malayo-India. The general lie of these areas is shewn in Map 2 (Plate XXXVII).

A few words may be said finally as to the Himalayan species. Of these *A. gigas* is Malayan and has been found in Java and probably in the Philippines. The common and ubiquitous Himalayan form is *A. lindesayi* which appears not to be known out of India. Two other Anophelines are also found in the Himalayan area which are not found elsewhere in India, *viz.*, the two tree-breeding species, *A. barianensis* (Holarctic) and *A. annandalei* (Malayan). The Himalayan fauna is not confined to the Himalayas but occurs also at high levels in the Assam and Peninsular areas. Thus both *A. gigas* and *A. lindesayi* occur in the Nilgiris and Palnis in South India though these are separated from the Himalayas by a wide extent of country quite unsuitable to these species which are restricted to high altitudes, *A. gigas* being scarcely ever found much under 5,000 or 6,000 feet. The occurrence of these Himalayan species in the isolated plateaus of Southern India is an instance of what is found also I believe in the case of distributional areas of some mammals, namely those of Alpine forms which exist now as outliers far to the south of India and have been considered as indicating the prevalence at one time of temperate conditions where now is a tropical climate.

There remains to say something as to the distribution of Indian Culicidæ other than Anophelines. In the space at my disposal I must be brief and so cannot enter as fully as I should like into this matter. In a Table is given an abstract of species occurring in Africa, Hindostan, Malayo-India and Malay with the number of species common to these areas. It will be seen that of 142 African and European species 12 only occur in India and of these 12 some are very widely-distributed species, *e.g.*, *S. fasciata*, *C. fatigans*. But of 161 Malayan species 56 occur in Malayo-India and at least ten in Hindostan. Of the 95 species recorded from Malayo-India 40 only are at present not recorded from Malay. At least twenty-two of these species are found also in Hindostan, forming the bulk of the relatively poor culicine fauna (30 species) of this area. These figures must not be considered by any means exact especially as regards the Hindostan area in which it is probable more species (mostly those of Malayo-India) will eventually be recorded. The figures show, however, numerically what is a self-evident fact to anyone accustomed to collect mosquitos. The rich fauna of moist tropical Malay is still found in forests and moist jungles almost wherever they occur in India. In the relatively drier parts of India this heavy jungle fauna largely disappears, leaving chiefly the swamp breeders, agrarian and domestic

forms. In the Trans-Indus and in the Himalayan area new faunas are encountered. The Himalayan area appears to be responsible for quite a number of the species restricted to India itself, notably species of *Ochlerotatus*. In this area it is curious to find in the North-Western Himalayas at a height of 6,000 feet or more and among oaks and pines such forms as *Toxorhynchites leicesteri* and *Orthopodomyia anopheloides*, which one associates with tropical conditions and which are Malayan species.

The close similarity of areas based on the distribution of mammals to those now brought forward in respect to the distribution of mosquitos is very striking. That there should be such coincidence in the case of forms so totally unrelated to one another in zoological position and methods of life appears to show that the distribution of forms of life in this case has been less the effect of diffusion of individual species, working so to speak independently, than of circumstances acting upon the great biological systems that are understood when one speaks of a fauna. As regards the causes of distribution of the different species of Indian mosquitos, even of the Anophelines, it is evident that we must primarily consider most of these species as belonging to a great Malayan faunal complex in whose history and fate that of the species has been involved. Similarly one must expect to find indications of an African faunal complex since it is known that at one time the so-called Siwalik fauna of African type existed in India and extended far into Central Asia. Of this we have not seen such striking evidence as might have been expected seeing that the Siwalik fauna succeeded the Malayan in North India and is usually considered Pliocene as against Miocene in point of time. In the case of the mosquito fauna of India one can almost see the eastward recession, due to drier climatic conditions, of a faunal area which once extended from Europe to the East. Yet apart from the history of the faunal complexes there is evidently much in the distribution of mosquitos due to special circumstances affecting individual species. Some of the Anopheline species, as I have shown, have very peculiar areas of distribution of which the explanation is not clear; yet these must have a definite significance. Why for example, do species stop at the Indus ? I have made somewhat of a study of the land changes in this area but without convincing myself that I have discovered any adequate reason for this. Why does *A. stephensii* exist up the Tigris and Euphrates and *A. culicifacies* not, and so on.

In conclusion, I may point out how important is our knowledge in regard to the Central Asian border of our area and how desirable are observations and collections from the Tibutan and Chinese borders.

References to Literature.

(1) BLANFORD, W. T. . *Journal of Asiatic Society of Bengal*, Vol. 39, Part 2, p. 336. 1870.

(2) Ditto The distribution of Vertebrate animals in India, Ceylon and Burmah. *Philosophical Trans. of the Royal Society*, Series B., Vol. 194, pp. 335-436. 1901.

—	African and European species.	Common species.	Hindustan species.	Common species.	Malayo-Indian species.	Common species.	Malayan species.
Stegomyia . .	11	1	6	6	12	5	8
Ochlerotatus . .	43	2	6	3	19	4	7
Armigeres and *Leicesteria*.	..	..	1	1	8	5	23
Culex . . .	29	5	10	10	13	11	25
Culiciomyia and *Lophoceratomyia*.	1	..	..	..	11	9	14
Tæniorhynchus .	7	..	..	..	2	2	3
Mansonia . .	3	1	1	1	2	2	4
Micrædes . .	3	..	..	..	8	4	9
Uranotænia . .	15	..	..	..	6	4	18
Toxorhynchites .	1	..	1	1	3	2	6
Theobaldia . .	3	1	3	..	.	..	..
Others . . .	26	2	3	2	11	8	4
TOTAL .	142	12	31	24	95	56	161

We are much indebted to Major Christophers for this most interesting paper. He has for many years paid special attention to mosquitos, which are themselves insects which are only too apt to pay too much attention to us. The time has hardly yet come, I think, when any general debate on the entomo-geographical fauna of India is possible. We need more knowledge and larger collections. Both our own collections and that of the Indian Museum are inadequate. We hope to be in a position to do so in the future. I cannot agree with Major Christophers that the insect fauna of the Nilgiris is Himalayan. Fifteen years ago, I drew attention to the great similarity of the faunas of Ceylon and the Khasis. I do not think it is a case of survival, but rather a case of migration. Fifteen years ago, before I came to India, I took part in an expedition to the islands of the Indian Ocean, in which the collection of insects was my province of the work, and during this expedition many striking cases of distribution were found. Not only strong fliers, which could cross wide expanses of sea by their own efforts, but also very weak

fliers were found unexpectedly widely distributed. As you know, the Plume-moths are my speciality. They are very weak-winged insects, but there is a species found in Florida and Central America, in West and South Africa, in the islands of the Indian Ocean, in the Indian region generally and in Australia. This insect is not a survival from a common fauna, it has not been introduced by man, as its food plant is a wild one, and must have been distributed by natural causes of which probably the most important are upper atmospheric currents.

Before Mr. Fletcher advanced this theory of distribution by atmospheric currents I had hesitated to mention a similar theory of my own, as it sounded too far-fetched. My place of residence in Ceylon is situated on the South-west side of the last range of hills terminating the mountain mass of the island in a North-westerly direction. There is therefore no high ground struck by the repeating monsoon after leaving Burma until it reaches this range. On several occasions during this period of the year I have taken insects belonging to the Burmese fauna, noticeably when once in January I took at one sweep of the net two conspicuous Stratiomyiads, *Allognosta assamensis* and *Acanthina azurea*, neither of which I had ever seen in several years previous and continuous collecting at this spot. As Wallace has pointed out, if only once in a thousand years a specimen is successfully transported by the action of wind over stretches of ocean, this is sufficient to account for this continuous distribution of a species; and the above instance is possibly such an arrival.

My work has been done on Arachnids and one group of beetles, not on Culicidæ, but the results are somewhat similar. I have been much puzzled by cases in which species appear to have crossed the Bay of Bengal, and upper air currents may perhaps afford the solution. On the other hand, whilst collecting at Barkuda island on the Chilka lake recently, I found many species previously only known from Ceylon and it occurs to me that many of these cases of discontinuous distribution are really due to insufficient collecting in intermediate localities. Many lines of inquiry seem to be needed for the full elucidation of zoogeographical problems. In Passalid beetles distribution is closely correlated with phylogeny. Passalids are very occasionally seen at light and probably very seldom fly. Consequently their distribution is likely to be of a slow and regular type. Among the species of one group of the Family occurring from Ceylon to Australia the most distantly related species occur on the one hand in Celebes and Borneo (which themselves are very different in faunal constitution) and on the other in the neighbouring Malacca islands. To these two areas they can be traced phylogenetically from Ceylon and Australia respectively, where

the primitive species of each region occur, these being much more like each other than are those occurring in geographical proximity. There appears therefore to have been a pushing out from a centre of distribution towards the middle of the Malayan Archipelago, whose luxuriant jungles are noted for their great wealth of different species. There have been some barriers to distribution which have checked this centrifugal tendency at various points, such as Palk Straits, the Gangetic plains and the Isthmus of Kra. Certain groups of Arachnida follow in the main this distribution but often their case is very complex. Certain Malaysian spiders extend into the Eastern Himalayas but not into Peninsular India. Others of the genus may occur in Peninsular India but not in the Himalayas.

I do not, of course, ascribe distribution in all cases to air currents, which cannot have much effect on heavy insects such as the Passalids, but certainly they play a large part generally. Even neglecting transport across wide stretches of ocean by the upper air currents, many insects can fly, or are carried by the wind, to quite unexpectedly long distances. When I was in a Survey Ship off the coast of Ceylon, we were running lines of soundings every quarter of a mile along the coast out from the beach to the 100 fathom limit and each night we anchored wherever we happened to be on our line when it became too dark to see our shore marks; often we were 10 to 12 miles from the coast. It was surprising to note how many insects came to the lights of the ship, and these included many small things, which one would think could not fly half-a-mile. In America experiments have been done by exposing sticky screens at light-houses off shore and it has been found that young Coccids, caterpillars, etc., are carried to unexpectedly great distances by the wind,—something like 27 miles, I think.

Is there any indication of the distribution of Anophelines being correlated with mammalian feeding habits?

General experience shows that Anopheline distribution is affected primarily by the presence of suitable breeding places. With the exception of certain species, *e.g.*, *Stomyia fasciata*, which is definitely associated with man, mosquitos are not usually specific in their choice of a mammalian host.

Whilst collecting on a tame bull at Coonoor I found that several persons standing around the animal were not bitten by *Anopheles gigas*, *A. aitkeni*, *Stegomyia trilineata*, a *Simulium* and a *Culicoides*. Neither were we bitten by these insects whilst collecting around the garden, waiting for the bull to be brought up. I know two rest houses in Ceylon both situated deep in the same jungle, near one of which there is a

resting place for carts; it is noticeable that at the latter existence on the verandah in the evening is tolerable, whereas in the other it is quite impossible.

I have heard of cattle being used for keeping malaria down in France.

A certain amount of association of species of mosquitos with particular mammals undoubtedly exists. *Anopheles fuliginosus* and *A. rossii*, for example, are mainly cattle feeders. *A. funestus* and *A. listoni* like horses but are much more attached to man. Some Culicidæ do not feed on mammals at all; certainly not on man.

Uranotænia is a genus of mosquitos said never to bite; but *U. pygmæa* is recorded as containing avian blood in Australia.

On two occasions I have seen *Stegomyia albopicta* prefer to suck a plain cake rather than the people at a tea table. The specimens were females.

Yet *Stegomyia* also very frequently goes to the tea pot on account of its warmth.

In one of his articles in the *Indian Journal of Medical Research* ("The natural host of *Phlebotomus*") Mr. Howlett showed the Gecko to be the natural host of *Phlebotomus*, and he considered the existence of the one might possibly be correlated with that of the other.

Certain species of crop pests occur in one place and not in another though the food plant is present in both. For instance the mango weevil, *Cryptorrhynchus gravis*, occurs in Eastern Bengal and not in Western, though the trees occur in both Bengals and mangoes are imported from East to West Bengal. Similarly I have noticed sugarcane borers occur in East Bengal and not in West although sugarcane is grown there also. The distribution of a species depends not on the presence of food only but also on a suitable climatic condition.

As most mosquitos show no special predilection towards particular mammals, there appears to be no noticeable correlation. But climatic conditions and occurrence of different kinds of breeding places appear to determine the distribution of the species. That random distribution of species occurs in various ways is true, but the places, to which the species are distributed, should have the particular breeding places suitable to them, as otherwise, the species is not likely to establish itself in the new locality.

The occurrence of some genera of Alpine plants in the Himalayas and in the Nilgiri Hills supports the theory of distribution during the glacial era. It is not likely that the seeds of these plants could be carried by the wind. The occurrence of *Anopheles gigas* in the Nilgiris and in the Himalayas may be a further illustration of a glacial era distribution.

I may mention that *Anopheles gigas* occurs also at Pachmarhi in Central India. To decide regarding insect distribution generally and even mosquitos in India would perhaps be premature. But I have brought forward facts regarding the distribution of Anophelines because these form an unusually suitable group for study and we have a unique amount of information regarding them. We have about ten thousand specimens at Kasauli and in the main their distribution in India is uniquely well known. In general, wind-distribution cannot, I think, affect the problem. The facts are sometimes, I think, only to be explained as relics of different geological ages. For instance, *Toxorhynchites leicesteri* is common at Simla at 6,000 feet and *Orthopodomyia anopheloides* occurs at Simla ; both these are not Palæarctic but Malayan.

I found *Toxorhynchites leicesteri* at Dunga Galli at 8,000 feet in May.

I should expect even on the Western Ghats that a Himalayan Anopheline fauna would exist on any localities of say over 6,000 feet.

I do not agree to the application of the term Himalayan fauna to such areas, whose fauna is not Himalayan but consists of species common to the hills of India at this elevation. I should rather describe it as a montane fauna.

In speaking of Himalayan species I purposely excluded forms like *Anopheles maculatus*, *A. theobaldi* and *A. willmori*, which occur in the Himalayas but are widely diffused low hill species. Even if we admit that *A. gigas* may be blown across from Burma to South Indian hill-tops we still are faced with the fact that *A. lindesayi* has never been recorded from anywhere on the Malayan side. It is dominant in the Himalayas but occurs also in South India.

27.—A PRELIMINARY NOTE ON NEW THORACIC APPENDAGES IN ANOPHELINE LARVÆ.

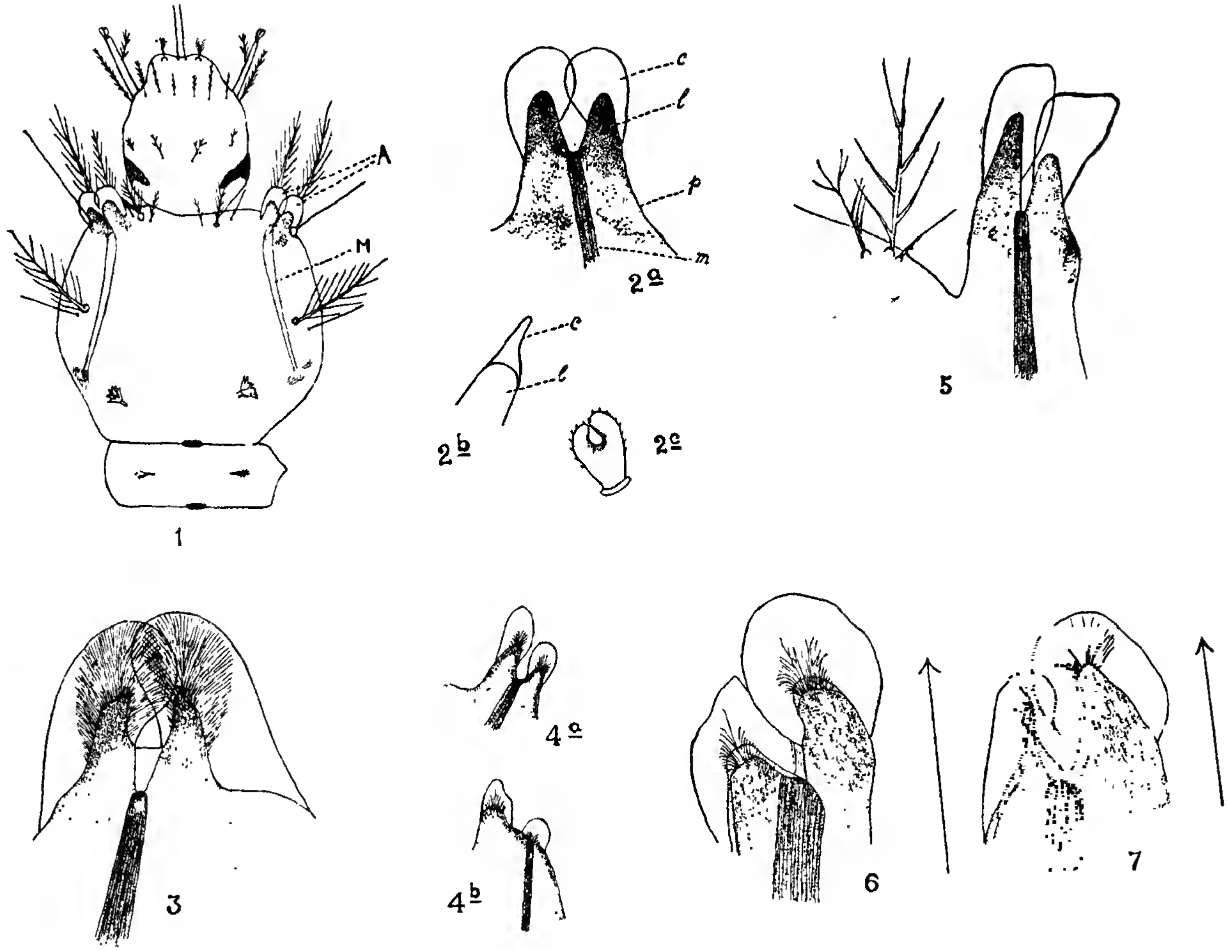
(Plate XXXVIII).

By M. O. TIRUNARAYANA IYENGAR, B.A., *Entomologist, Bengal Malaria Research.*

A paired contractile appendage has been observed on the dorsal anterior region of the thorax of the Anopheles larva, the structure, position and movement of which are herein described. The appendage has a basal pedicel which is produced apically into two finger-like lobes. Each of these lobes is provided with a thin lamellar expansion of the cuticle as seen in Plate XXXVIII fig. 2*a*. The appendage is provided with a muscle which is attached to the cuticular region between the two lobes, and when the muscle contracts, the lobes move towards each other. But it usually contracts to a much greater extent, and as a result the whole appendage is withdrawn into the thorax. This very rapid movement is quite frequent and can be seen in living larvæ especially of those of *Anopheles sinensis* or *A. barbirostris* in which species these appendages are well developed.

In the normal position of the larva, the appendages cannot be fully seen as only the tips of the lobes can be seen protruding beyond the profile of the thorax even in the best developed forms. If however a cover-glass is dropped lightly on the larva and by a slight movement of the cover-glass the larva is turned to one side the whole appendage would come into view and the details of its structure can then be made out. It frequently happens that the whole appendage is withdrawn into the thorax. In such a case, nothing can be seen except a depression in the thorax, and to see the appendage it will be necessary to wait till the contracted muscle relaxes again and the appendage is exerted. To have a clear view of the cuticular lamina of the lobes it would be necessary to use a very low illumination. They are highly transparent and are wedgeshaped when seen edge-wise.

The muscle controlling the movement of the appendage is a long transverse one starting from the sub-posterior ventral region of the thorax and ending at the dorsal anterior part of the thorax in the appendages. The appendages themselves seem to take their origin from the anterior sub-dorsal region of the meso-thorax rather than from the prothorax which is very small in comparison with the mesothoracic segment. But as there are no clear lines of demarcation between the



THORACIC APPENDAGES IN ANOPHELINE LARVÆ.

1, diagram of head of larva of *Anopheles barbirostris*, showing position of the thoracic appendages, A, thoracic appendage, M, muscle attached to it; 2, diagram of a thoracic appendage, 2A, dorsal and, 2B, side view of a lobe, 2C, "Flabellum" of Nuttal and Shipley, P pedicel, L lobe, C cuticular expansion, M muscle-strand; 3, thoracic appendage of *A. sinensis*; 4, right thoracic appendage of *A. stephensi*, (a) dorsal and (b) oblique views; 5, shoulder-hairs and right thoracic appendago of *A. maculipennis*; 6, left thoracic appendage of *A. listoni*; 7, left thoracic appendage of *A. fuliginosus*.

different thoracic segments, it has not been possible to say this with a precision. It is hoped that further work may throw light on this question. The sizes of the appendages vary with different species. While in *A. sinensis* and *barbirostris* the lobes are equal, in most of the other species the lobes are generally not equal and the inner lobe is the better developed of the two in such cases (Figs. 3-7).

As many as ten Indian species of *Anopheles* have been examined and all of them have these appendages. *A. maculipennis* and *bifurcatus* larvæ from England (received through the courtesy of Professor G. H. F. Nuttall) were also examined and were found to have these appendages quite characteristically. Other genera of the Culicidæ that have been so far studied, including *Culex, Stegomyia, Armigeres* and *Toxorhynchites,* do not have them, not even their vestige. It appears probable that these appendages are characteristic of the larvæ of the Anophelinæ.

It is curious that all previous workers on mosquitos have failed to mention anything about these organs, with the solitary exception of Nuttall and Shipley (*Journal of Hygiene* Vol. I.). Even these authors only mention the occurrence of a " curious, flattened, notched process " on the dorsal side of the thorax of *A. maculipennis* and this is evidently a reference to the appendage above described.

The investigation in its present state does not warrant even a conjecture as to the homology or function of these appendages. The purpose of their movement has not yet been understood. When a larva creeps forward on a slide these organs contract with every forward creep. In the natural condition the tips of the lobes touch the surface film of water. Imms suggests that the " curious, flattened, notched process " of Nuttall and Shipley are probably vestiges of prothoracic spiracles (*Journal of Hygiene*, Vol. VII, p. 294). This seems improbable. Further work is being done on the anatomy, homology and function of these appendages. Other species and the further development of these appendages in the pupa and adult are also being studied.

Do these appendages appear at once or after a moult ? **Mr. Sharma.**

I have not seen them until the second instar. When the larvæ are irritated the processes contract within the thorax. **Mr. Iyengar.**

You might try gradual anæsthetizing as used for highly contractile Protozoa so as to kill the larvæ with the appendages extended. **Mr. White.**

The method used for mounting Rotifers in an extended condition, by very gradual addition of cocaine to the water, might also be useful. **Mr. Fletcher.**

I have done no work on the embryology of these appendages, but this is now proceeding. **Mr. Iyengar.**

KALA-AZAR IN ASSAM.

Mr. Awati gave a few remarks on his present Survey of house-living insects in connection with Kala-Azar in Assam. He works on three lines :—

(i) Study of the physical aspect of the village.
(ii) Inquiries regarding insects found in houses.
(iii) Inspection of the houses in cases in which this is permitted.

He stated that the villagers have no knowledge of insects found in their houses except " bed bugs " and occasionally lice. On one occasion *Conorhinus rubrofasciatus* has been found in the bed of a patient.

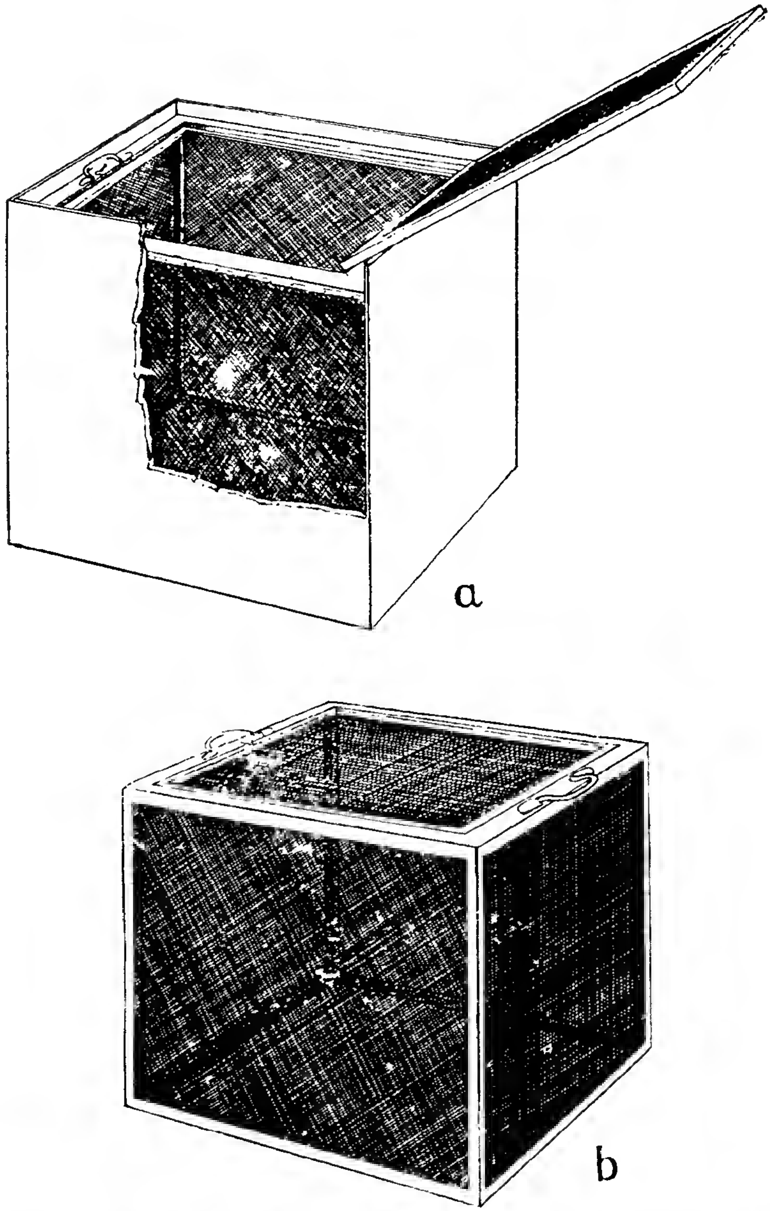


Fig. 1.—New Mosquito trap, (*a*) open and (*b*) closed and removed from outer case.

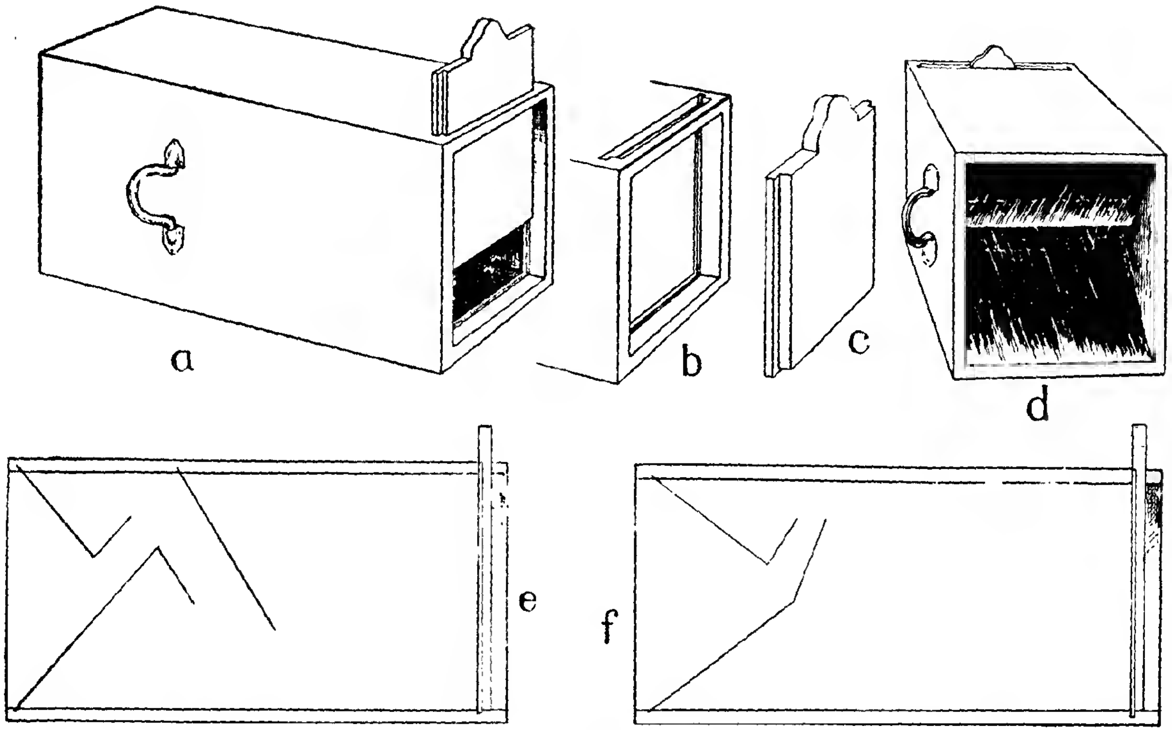


Fig. 2.—Suggestions for Mosquito traps. *a*, *b*, *c*, details of door at back ; *d*, front view showing glass panes ; *e*, sectional view showing arrangement of glass panes ; *f*, section of an alternative trap, showing arrangement of glass panes.

28.—TRAPS FOR MOSQUITOS.

(Plate XXXIX).[1]

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist.*

The fact that mosquitos hide during the daytime in dark situations such as are provided in the ordinary bungalow by cupboards, boots, book-cases, etc., is a matter of ordinary daily observation in India and attempts have been made with some success to utilize this habit to trap and destroy them. An ordinary box provided with a hinged lid, which is left slightly ajar, is a simple means to this end, and this method is slightly elaborated in the Watson pattern of mosquito box-trap which consists of a box lined with black cloth and with a hinged lid which can be held half open by means of a metal clip, the lid being provided with a hole fitted with wirenetting through which a liquid, such as chloroform or benzine, can be poured to kill off the mosquitos caught in the box. The method of use of such traps is simple and consists of placing the box, with the lid held open by the clip, in a suitable corner overnight and letting down the lid in the morning when the mosquitos have retired for the day into the dark cavity thus provided for them. They are then poisoned by pouring in the necessary liquid through the hole in the lid. Such a box-trap is often very effectual in catching mosquitos when these are present in large numbers but it suffers from the defects :—(1) it is not possible to see what is in the box ; it may happen that this is empty, (2) it is necessary to use a liquid poison such as chloroform or benzine and these are not always available in the ordinary household, (3) if the box is not thoroughly aired afterwards, a trace of the smell of the poison employed may remain in it and repel mosquitos from entering it on a subsequent occasion.

To obviate these defects, some five years ago I designed a new type of box-trap (Plate XXXIX, figs. 1*a*, *b*), which consists essentially of a wooden skeleton of a box with a hinged lid, covered over on all six sides with black mosquito-netting. This skeleton box is contained inside an open-topped wooden box which is painted black on the inside. The whole is then placed in a suitable position overnight and left with the hinged top of the inner box open. In the morning, when the mosquitos have settled down, the hinged lid is closed and fastened with the metal hook-fastener, and the inner box can then be lifted out by the handles provided for this purpose. It can then be seen at once what the catch is. It now remains to kill the captured mosquitos and

this is easily done in the hot weather, when mosquitos mostly seek refuge in houses in the daytime, by placing the inner box on the bare ground in the blazing sun. In really hot dry weather the mosquitos are all killed within a few minutes. When the air is damp, this is not so successful, but every ant in the vicinity hastens to the feast, gets inside through the mosquito net, and the mosquitos rarely survive for very long. In the last resort, as in very wet weather, a little benzine or petrol may be poured into the trap (both boxes) and a piece of cardboard laid over the top to keep in the fumes. This type of trap has been tried at Pusa and at Nagpur with considerable success.

Both these types of trap possess one common disadvantage in that they require the human element to look after them, reset them overnight and deal with the captures daily. It would be a great advantage if we could have a purely mechanical trap which would catch mosquitos regularly without needing daily attention. This is a line on which I have made experiments and, although these have so far not been very successful, it may be useful to give some idea of the line on which I have worked as it is probable that a successful trap could be evolved on this principle. I took a long box and fixed inside it glass strips, stretching from side to side, as shown in the section of the box (Plate XXXIX, figure 2*e*), one end of the box being of course open; the other end is provided with a sliding trap-door, as shown in detail in Plate XXXIX, figures 2*a-c*. The complete box, seen from the open end, is shown in figure 2*d*. The inside of the box is painted black. My idea was that the mosquitos, when looking for a suitable dark place in which to spend the day, would be able to find their way inside the box past the glass strips, which slope inwards, but that these strips would prevent their exit; they would thus stop in the box until they died, the accumulated corpses being removed occasionally through the trap-hatch. However, in practice this has not been very successful so far. Possibly a little variation in the position or number of the glass strips might make it quite effective. Another design, which has not yet been tried, is seen in Plate XXXIX, figure 2*f*, in which also the idea is that mosquitos may be able to find their way in but be unable to discover the means of egress.

Should it be possible to secure a mechanical trap on these lines, it would be useful in the reduction of domestic mosquitos in houses, as it would only require to be placed in a suitable position and left there practically without attention.

The ordinary form of box-trap, it may be added, is also likely to be of considerable use in the prosecution of regular mosquito survey-work.

There is one point that I may add, and that is with regard to the most suitable colour for mosquito-traps. These have always been coloured black, but it is by no means certain that black is the most attractive colour, and experiments are badly required on the colours which are most attractive to mosquitos, either generally or to particular species or groups. I think it not unlikely that dark-blue will prove still more attractive than black.

29.—SURRA AND BITING FLIES: A REVIEW.

(Plate XL).

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. *and* R. Senior-White, F.E.S.

The serious losses to army transport animals during the recent War led to the appointment by the Government of India of a special Surra Committee, in connection with whose work the late Imperial Pathological Entomologist received orders to carry out the following investigations :—

(*a*) The continuation of research on fly repellents.

(*b*) The preparation of maps of the areas affected by Surra.

(*c*) The carrying out of a fly survey.

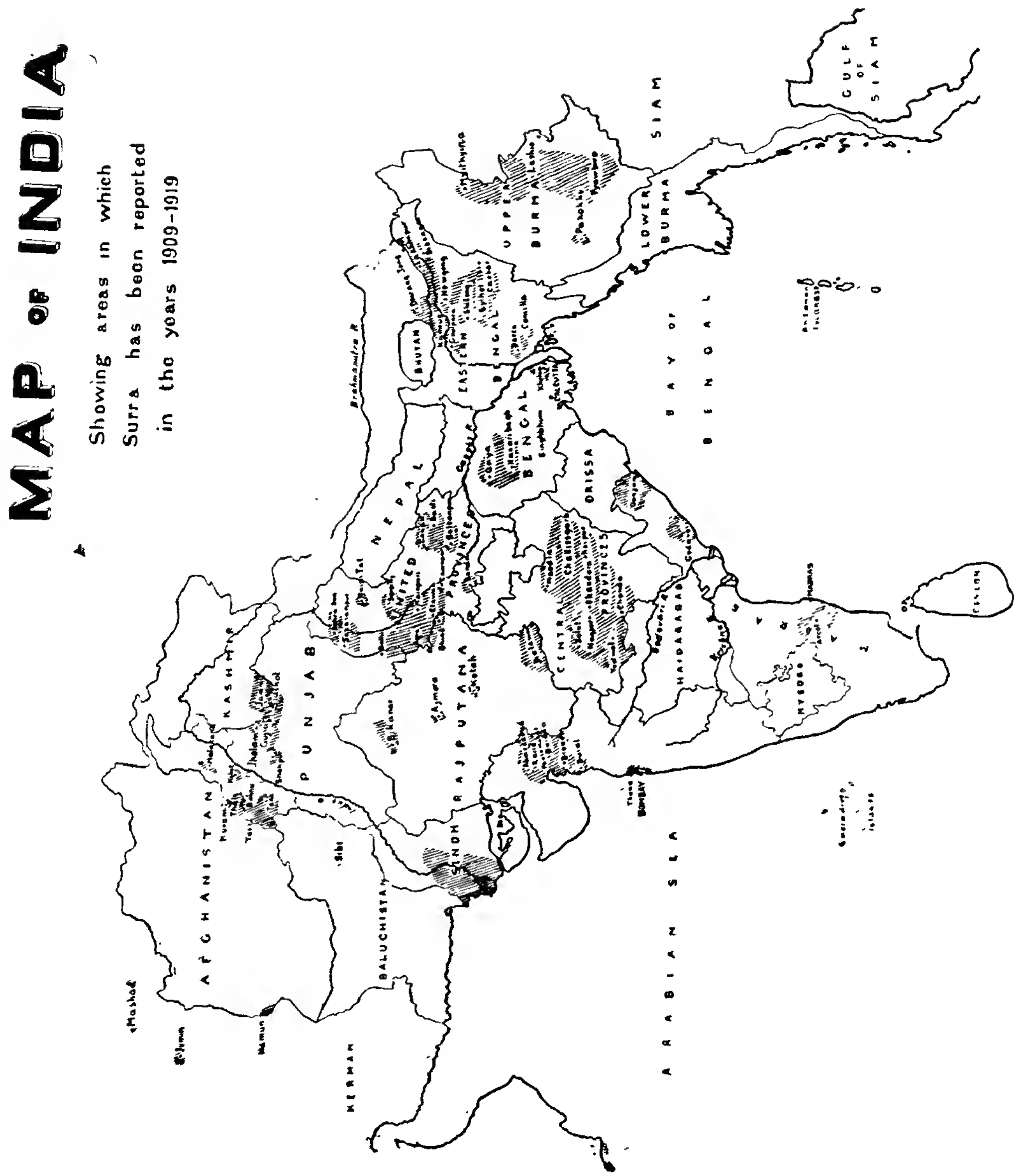
(*d*) The study of Tabanid life-histories.

(*e*) The preparation of a review of the correlation between rainfall and Surra in 1919.

In endeavouring to discover what had been actually done to carry out these lines of work, we have had to put into order a mass of scattered papers in order to prepare a report of the present position of affairs for the Surra Committee, and in the course of so doing we have been led to go over a good deal of literature dealing with the question of Surra in India and its connection with Biting Flies and have thought that it might be of interest to this Meeting to give a *resumé* of what is actually known and what has actually been done on this subject, which is an important one, in Northern India especially. It should be understood that we do not claim to say anything new on the subject of Surra nor to do more than to give a brief review of the literature on this subject so far as India is concerned. On points demanding a knowledge of protozoology we have had the kind assistance of Dr. Pringle Jameson whose help in this subject we would gratefully acknowledge.

Surra, literally meaning "rotten," is a protozoan remittent fever, accompanied by emaciation, anæmia and debility, and characterized by the presence of Trypanosomes in the blood during an attack of fever. The causative Trypanosome is *Trypanosoma evansi*, which was discovered at Dera Ismail Khan in 1880 by Griffith Evans, who first demonstrated the Trypanosomes in the peripheral circulation of affected camels. Besides camels, it occurs naturally in cattle, buffalos, mules, horses, rats, jackals and dogs, and under laboratory conditions has been found capable of infecting guinea-pigs, rabbits, mice, goats and monkeys.

PLATE XL


MAP OF INDIA
Showing areas in which
Surra has been reported
in the years 1909-1919
AFGHANISTAN
BALUCHISTAN
KASHMIR
PUNJAB
RAJPUTANA
SINDH
NEPAL
BHUTAN
UNITED PROVINCES
EASTERN BENGAL
BENGAL
ORISSA
CENTRAL PROVINCES
HAIDARABAD
MYSORE
UPPER BURMA
LOWER BURMA
SIAM
GULF OF SIAM
BAY OF BENGAL
ARABIAN SEA
CEYLON
KERMAN
BOMBAY
MADRAS
Brahmaputra R.
Mashad
Sibi
Bikaner
Ajmere
Andaman Islands

There is also some evidence that pigs and elephants are naturally infected, and it is probable that systematic examination would add other wild animals to the list of natural carriers.

Surra is by no means confined to India. It occurs probably throughout South-eastern Asia and has been recorded from India, Burma, Federated Malay States, Indo-China, the Philippines, Java and Sumatra, and also from Mauritius, whither it was imported with Indian cattle. A striking point about it is its occurrence in definite areas, commonly called Surra belts, which Pease (1906) states are "lowlying marshy lands, subject to partial inundation and subsequent partial drying up, covered with rough grass and jungle." Such conditions are not, however, apparently a necessary accompaniment of an outbreak of Surra, as cases have occurred in ponies and dogs in Madras City, where they do not exist, and in North Bihar, where such conditions do exist, Surra appears to be unknown. Many observers are agreed that the limits of Surra belts are sharply, or fairly sharply, defined but there seems to be little exact information on record regarding their occurrence and delimination in India. In this connection we have prepared a map (Plate XL) from the reports on file at Pusa showing the areas in which Surra is reported to have occurred during the last ten years*. It has not been found possible, in the absence of a standard and from the information available, to indicate the intensity of occurrence in any area. Further, when studying the map, it gives one the impression that many areas shown as isolated are in reality portions of some main area and, if more detailed information had been available, would have been shown as such. Discontinuity of distribution is probably more apparent than real and is probably largely due to absence of reports rather than to absence of the disease. Subject to this remark, it will be seen that, north of the parallel of Bombay, the disease is absent only from the desert areas and from Bihar north of the Ganges. The occurrence in South Madras of an isolated area of fairly constant infection is most interesting. Surra also occurs in Central Ceylon (not shown on the map).

The most interesting and most important point about Surra is with regard to its method of transmission from one animal to another. Given an animal whose blood contains *Trypanosoma evansi* and another animal whose blood is free from this Trypanosome, how can the parasite pass from the infected animal to infect the hitherto healthy one? Now, with regard to this, before considering the various experiments that have been done and the theories that have been advanced, we must

* Since this paper was read, Surra has also been reported to occur in Ceylon, which should therefore be shaded in the map.—T.B.F.

realize that the production of disease is a mere accident from the point of view of the Trypanosome, an occurrence which is fatal to itself as well as to its involuntary host, should the latter die. In the case of wild animals which carry the Trypanosomes producing Sleeping Sickness and Nagana in Africa, these parasites live without doing harm to their hosts although they produce fatal diseases when introduced into hosts which are not used to them and which cannot tolerate them and hence become diseased. It has been found by cultural methods that normal English cattle have Trypanosomes in their blood and it seems certain that in India cattle and buffaloes form a normal reservoir for *Trypanosoma evansi*, without its causing them any particular harm. There seems to be little exact particular information regarding the degree or distribution of such tolerant infestation in either domesticated or wild animals in India, but it is as well to realize at the outset that infection in the case of hitherto healthy animals may be derived, not only from other similar animals which are actively showing the disease, but from other animals which may appear quite healthy. To detect the presence of the parasite in such apparently healthy animals is not always easy, as it may only appear occasionally in the peripheral circulation; the Twentyfourth Annual Report of the Bureau of Animal Industry, United States of America (1907), for example, reports a case in which Indian cattle were imported into America and examined daily, when it was found that the Surra organisms only appeared periodically and could be found during a period of 2 to 4 days and then remained absent for another period of 5 to 6 days, after which they reappeared. In the case of the camel, Cross (1907) distinguishes an acute form of Surra, in which the disease runs a rapid course, the animal dying in a few months, and a chronic form, in which the disease is of long duration, the animal lingering on from one to three years, becoming gradually more and more emaciated and debilitated until death supervenes. So that we get cases (1) in which the health of the host is apparently quite unaffected, (2) in which the host dies rapidly as the result of infection, or (3) cases intermediate between (1) and (2). Pease (1906) states that Camel Surra is an attenuated form of horse Surra, and there may be differences in strains of the Trypanosome or in individual susceptibility of the host; but these are questions beyond the scope of Entomology and which we do not intend to pursue further.

A large mass of information on Surra, especially in horses, was accumulated over twenty years ago by Lingard, but his results were inconclusive and need not be referred to further. Rogers (1901) seems to have been amongst the first to carry out experiments on transmission by biting flies. The investigation was done at Muktesar [and as he

states that he used "horse flies" which were only available during the 3 or 4 hottest months, presumably Tabanidæ are meant], and as a result of his work he concluded that a full meal seldom infects, but an interrupted feeding does.* He found also that material containing the organism when infested can only infect through accidental lesions of the mouth and nose. Pease (1906) described Tibarsa Surra in the camel and stated that in 1903 eight camel corps lost 1792 animals, being 22·4 per cent. He proved that the disease is necessarily a wound infection. In 1906 also Lingard stated that cattle are the reservoirs, carrying the Trypanosome for nine to twelve months and that Tabanidæ and Hippoboscidæ play an important part in the dissemination of Surra, but that *Hæmatopinus cameli* appears in some instances to be the intermediate host; Lingard experimented with *Tabanus* "*tropicus*," *Stomoxys* and Hippoboscidæ and found no species capable of carrying the disease during the non-Surra time of year; the question of transmission by leeches was considered and left open for lack of evidence; he stated that canines may help to form the reservoirs during the non-Surra period, as they show the disease from January to April, and that rats all harbour immature forms of the parasite and their blood is virulent when inoculated, so that rat-fleas may possibly carry the disease on rare occasions.

Holmes (1906) discussed all the theories, including that of mechanical transmission, and decided that they were all inconclusive; whilst not stating that a developmental cycle occurs in the invertebrata, he considered that that was the best line of research to pursue.

Patton (1909) described the life-cycle of *Crithidia tabani*, a flagellate found in the intestinal tracts of *Tabanus hilaris* and of an unnamed *Tabanus*, and it is at least suggestive that this parasite was not found in flower-feeding Tabanidæ and mammalian blood would thus appear essential to its development. [With regard to this paper we would remark that the cycle as shown on the place seems correct but, whilst there is nothing in the figures to prevent the stages shown from being those of a Trypanosome at some period of its lifehistory, on the other hand there is nothing to suggest that they are.]

Leese (1909) wrote a long and important paper on experiments regarding the natural transmission of Surra, carried out at Mohand in 1908. This paper was subsequently reissued in Memoir No. 2 of the Civil Veterinary Department and this reissue was illustrated by coloured figures of the Tabanid flies found. Some of the specimens of these

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* Better an interrupted feeding on the same animal.

flies have lately been found in the Pusa collection and we are able to add the following regarding their identification :—

Number on Plate.	Number on label of specimen.	REMARKS.
1	1	*Tabanus ditæniatus*, Mq.
2	2	,, *bicallosus*, Ric.
3	3	,, near *discrepans*, Ric.
4	4	,, near *oxyceratus*, Big.
5	5	
6	6	,, ? *flavicinctus*, Ric.
7	7	,, *virgo*, Wied.
8	8	,, *orientis*, Wlk.
9	9	,, *bicinctus*, Ric.
10	10	,, *n. sp.* in Ricardo's Group I.
11	11	,, *n. sp.* near *siamensis*, Ric.
12	12	,, *jucundus*, Wlk.
13	13	,, near *cordiger*, Wied.
A	A	
B	B	*Hæmatopota ? lata*, Ric.
C	C	
D	D	
E	...	*Chrysops designata*, Ric.*
...	E	*Hæmatopota sp. n.* in Ricardo's Group II.

The specimens are (except No. 6, which is a male) undoubtedly those illustrated, as specimens shown on the plate as lacking the antennæ, and other peculiarities, correspond exactly with the figures themselves, but as they are now nearly 13 years old, and are all single specimens in not too good condition originally, the identifications are given with considerable reserve in many cases.

In this paper Leese commenced by stating that, "it being now well established that in laboratory experiments *Tabanus* is capable of conveying the Trypanosomes from an infected animal to a healthy one, if both animals are bitten within a short interval of time," and "it being known from an investigation of a natural outbreak of Surra

at Kathgodam that Surra can continue to spread among horses in the absence of *Tabanus*." The losses occurred at Mohand during and after the Rains and it is stated that no less than 92 out of 102 ponies were destroyed by Surra on the Naini road during a year. Now that dak traffic there no longer occurs a few ponies are kept in contact with cattle without loss throughout the Rains. Infection arises through "reservoirs" working through an area. Game is not evidently a "reservoir." Disease was started by inoculating an imported pony with camel strain. Complete screening of ponies was found absolutely effective, whilst Surra appeared in unscreened controls in 38 to 51 days. The food-transmission theory (including the theory of transmission by infected rat excrement) was completely disproved, as screened and unscreened animals were all fed from the same store. Harness and galls as a source of infection were also excluded, as the ponies did no work, but transmission can occur, without a fly intervening, from wound to wound. Lice were not present on the ponies and ticks (*Hyalomma ægyptium*) were equally prevalent before and after the break of the Rains. As regards the prevalence of biting flies, *Tabanus*, *Hæmatopota*, *Stomoxys*, *Hippobosca* and *Hæmatobia** all occurred during the hot weather from 1st May until the Rains broke on 28th June, and the same genera occurred after that date with addition of *Chrysops* and *Lyperosia* and many mosquitos. Of these flies, *Hæmatobia** may be ruled out, as it was more prevalent before than during the Rains; *Hippobosca* can at most only cause an occasional case by mechanical transmission; *Chrysops* and *Lyperosia* were so scarce that it was considered that they could have played no part. Cross and Leese (*Journ. Trop. Vet. Sci.* III 163) found fresh cases occuring in the absence of *Tabanus*, *Hæmatopota* and Sand-flies, but *Stomoxys* and mosquitos came under suspicion. Dissection of the gut of mosquitos showed only Trypanosomes degenerating, and this observation applied to all genera of flies examined. Mechanical transmission experiments were conducted over times ranging from half to three minutes, and it was found that *Tabanus* has far more power to transmit mechanically than has *Stomoxys*. Oxen (and perhaps, buffalos) are the chief reservoirs for infection of horses. Camels mainly infect only camels, as they are preferred by flies. Leese points out that the general distribution of *Stomoxys* is against its playing any part, except when horses are standing in lines.

Fraser (1909) stated that, in the Federated Malay States, mechanical transmission is only affected by immediate transfer from host to host by four species of *Tabanus*, and not by *Hæmatopota* or *Stomoxys*.

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* Judging from a specimen now in existence in the Pusa collection and collected at Mohand in July 1908, the fly here referred to as *Hæmatobia* is really *Stygeromyia maculosa*, Aust.

Schat (1910), in a paper on Surra in Java, described the multiplication of the parasite in the bodies of certain flies and described and figured a sexual cycle, only an asexual cycle occurring in mammalian hosts. He concluded that the chief carrier is *Stomoxys calcitrans*, but that it may be carried occasionally by *Tabanus tropicus* and *Hæmatobia* (*Lyperosia*) *exigua*.

Bruce, Hamerton, Bateman and Mackie (1910) concluded that in the case of *Trypanosoma pecorum* [which is closely allied to Surra but apparently distinct, as it is non-pathogenic to guinea-pigs] in Central Africa, *Stomoxys* was always numerous but that it is inconceivable that it should act as a carrier, as infected and healthy cattle were placed together for a whole year in the presence of " exceedingly numerous " *Stomoxys* without a case occurring. They conclude that the carrier is unknown but probably a *Tabanus*.

Baldrey (1911) concluded that there is a developmental cycle, which he illustrates, and which he states can occur in species of *Tabanus* and in *Stomoxys calcitrans*. [With regard to this, we would remark the figures of " conjugation " probably represent a process of division and that the other figures are poor and prove nothing. If, however, a division process occurs in the fly, this rather tends to show that the Trypanosome is healthy and is not degenerating as asserted by Leese].

Mathis and Leger (1911) state that Surra occurs in Indo-China in cattle (of 256 examined, Trypanosomes were found in 5 presenting no obvious symptoms), buffalos (of 216 examined 2 were found infected) and horses (1 found infected out of 42 examined). Attempts to transmit to a horse by means of *Tabanus* failed.

Neveu-Lemaire (1912) gave a general account of Surra and stated that in Mauritius Daruty de Grandpre has incriminated *Stomoxys nigra* as a carrier of Surra. [The only Indian Tabanid known to occur in Mauritius is *T. ditæniatus*, Macq., which is widely distributed throughout Africa, the Mascarenes, India, China and Japan].

Leese (1912) stated that *Lyperosia minuta* is a transmitter in the absence of other biting flies and that transmission is quite mechanical. [We should, however, like to have further evidence regarding the absence of Tabanids and biting flies other than *Lyperosia*].

Mitzmain (1913), from experiments in the Philippines, concluded that *Tabanus striatus* transmits Surra mechanically over short intervals, that Trypanosomes are not transmitted hereditarily in the fly, and that they are not transmitted by merely sucking with the labellum. [This last observation would seem to rule out the hæmatophagous Muscids. Mitzmain's experiments were done with bred flies but he

gives no details as to whether they were bred from the egg or from larvæ collected].

Patton and Cragg (1913) quote another paper by Mitzmain which we have not seen and state that he " has recently carried out a long series of experiments with this fly [*Stomoxys calcitrans*] in order to settle this question [the carriage of the trypanosome of Surra.] His results indicate that *Trypanosoma evansi* does not develop in *Stomoxys calcitrans*, and that it plays no part in the transmission of the parasite."

We may here perhaps refer to some unpublished work carried out at Bareilly and Kathgodam by the late A. W. Shilston and P. G. Patel who found that *Tabanus albimedius* and *T. striatus* could infect by complete as well as by interrupted feeding [Presumably caught flies were used, which would show that these are infective over a considerable period, as they only feed every few days]. *T. albimedius* was found to be infective 24 hours after feeding but not after a longer period. *T. striatus* was found to carry trypanosomes after 72 hours. Another small species of *Tabanus* (like *virgo*) was not found to carry. Experiments with *Philœmatomyia crassirostris* showed that this fly did not infect after a longer interval than 7 minutes during an interrupted feed, but, in the case of male flies only, trypanosomes were found active in the gut up to 28 hours after feeding, and the gut contents, when injected into guinea pigs after 24 hours, proved infective; in the case of the female flies, the trypanosome was found to die off in 2 hours.

Cross (1917) gives a general account of Surra in the camel and states that " in order for Surra to spread two factors are necessary :—

(1) the reservoir (*i.e.*, a camel infected with surra)
(2) the transmitting agent (*i.e.*, bloodsucking flies, the most important of which as transmitters are the Tabanidæ.

" If either of these two factors are wanting, the disease cannot be spread from the surra-infected animals to the healthy. If, on the other hand, there is a surra-infected camel amongst a batch of healthy camels and Tabanidæ are present, the fly while sucking the blood (containing the Trypanosome) from the surra-infected animal may be dislodged and infect a healthy camel ; during the act of biting this camel, he inoculates the latter with surra. This is known as direct or mechanical transmission. It has been proved by experiment that Surra can be transmitted in this way, and under favourable conditions (*e.g.*, when camels, amongst which are surra-infected ones, are herded together and blood-sucking flies are present) there is no reason why the disease should not be transmitted in this way ; but whether this is the usual method of transmission or whether the trypanosome does not undergo a cycle in the fly is still undecided................

"If direct transmission is the means by which Surra is spread from camel to camel, any blood-sucking fly may transmit the disease, and considering the number of blood-sucking flies in India and the number of reservoirs of Surra, it is difficult to imagine that a single camel could have escaped becoming surra-infected. It is probable that the trypanosome undergoes a cycle in the fly (and in a particular species of fly only), a percentage only of these flies being capable of infecting healthy camels—*i.e.*, the cycle is not completed in every one of the flies that has fed on blood containing trypanosomes.

..............."From practical experience there is no doubt that the most dangerous flies in the spread of Surra from camel to camel are the Tabanidæ."

Patton (1920) suggests that transmission occurs through the mucous membrane of the mouth from *Crithidia* voided from the rectum of *Tabanus*.

On going over these various papers, the chief point that emerges is the very wide difference of opinion held by various investigators on almost every point. Some observers declare that transmission is purely mechanical, others that a developmental cycle occurs in the insect transmitter; some implicate *Stomoxys*, others declare that *Stomoxys* is unable to transmit at all; in fact, there is hardly a statement made by one observer that is not directly contradicted by another.

Before considering these views further at this point, we will diverge for a short while and run briefly over a few of the more salient facts connected with another Trypanosome disease on which a great deal of investigatory work has been done. An interesting case, in many ways analogous to that of Surra, is furnished by Sleeping Sickness, which is happily so far restricted to tropical and subtropical Africa. Sleeping Sickness is caused by a Trypanosome, *Trypanosoma gambiense*, which is carried by a biting fly, *Glossina palpalis*. The distribution of this disease was originally restricted to West Africa, where there is some evidence that the negro population has acquired a certain degree of immunity (more marked in the case of another closely related disease produced by *Trypanosoma nigeriense*, which causes only a mild form of disease in man), but when equatorial Africa was opened up the disease was carried eastwards to Uganda, where it caused great mortality and from its first appearance in 1901 up to 1905 killed off over 200,000 people, whole villages being depopulated. The species of *Glossina* have a life-history very similar to that of our species of *Hippobosca*, the egg hatching inside the female fly and the larvæ being extruded only when ready to pupate, pupation taking place in the ground in soil which is loose and dry, well shaded but with the surface thoroughly

ventilated, within a few yards from the water but beyond its reach. As such a combination of characters is only to be found in definitely limited areas, the distribution of the fly is limited to forested and humid country and is often very sharply marked. It has been found in Uganda that *Trypanosoma gambiense* is carried normally by the *situtunga* antelope (*Tragelaphus spekei*), which, with other wild animals generally, is immune to the effects of the presence of this Trypanosome, which has a cycle of development of from 18 to 45 days in *Glossina palpalis*, after which the fly is infective whilst it remains alive up to about 75 days; development takes place in the gut of the fly, whence the parasite passes into the salivary glands, and thence into the blood of its next host. In the case of monkeys infection has been obtained by mechanical transmission by means of *G. palpalis* if the transference of the flies from the infected to the healthy animal is instantaneous, that is, by "interrupted feeding," but this mechanical transmission does not take place if an interval of time elapses between the two feedings, and mechanical transmission, though possible, plays a very small part in the spread of Sleeping Sickness. When the *Glossina* alights to feed, it selects a suitable place and inserts the proboscis, which is then withdrawn slightly and blood is sucked up; "almost at once the excess of fluid is exuded as a bead at the posterior end of the body, so that the fly is enabled as it were to have a larger feed of corpuscles than if it were compelled to retain all the fluid part." (Carpenter, pp. 34-35). Even when its natural host, the *situtunga* antelope, is present, *Glossina palpalis* derives only about 25 per cent. of its food from mammalian blood, the remaining 75 per cent. being derived from the blood of non-mammals, mostly lizards and crocodiles. The chances of an individual fly being infected with *Trypanosoma gambiense* is therefore minute, for every fly does not feed on a buck nor is every buck infected. Also, as Miss Robertson has shown, even if the buck is infected the Trypanosome is not always in a condition ready to multiply in the fly and also every fly that ingests Trypanosomes is not a suitable medium for their further development. Carpenter found that, in the absence of the natural host (the *situtunga* antelope), as many as 5,765 flies of *Glossina palpalis* failed to cause infection in a monkey; whilst in the same locality, three years later, after the *situtunga* antelope had found their way there, "the flies were again tested and found to be infected, for after 2076 had fed upon a monkey it showed the Trypanosome in its blood," (Carpenter, p. 29). A very interesting and suggestive point which Carpenter notes is that "besides Trypanosomes bacilli are often found in countless numbers in the gut of the fly, but in a different part. Nevertheless there appears

to be some inverse relation between the two, for out of six hundred flies at Jinja, in only 3·4 per cent. of flies containing bacilli were Trypanosomes also found, and in only 6·1 per cent. of flies containing Trypanosomes were bacilli found. Bacilli were present in 19·3 per cent. and Trypanosomes in 11 per cent. of the wild flies. Thus there is marked incompatibility between the two.

"Since I have found bacilli in the gut of freshly hatched flies, and even in pupæ, their presence in the fly may have something to do with the fact that only a few out of a batch of flies fed upon an infected animal at the same time will prove suitable hosts and will subsequently be found to contain Trypanosomes. It may be that the presence of bacilli in numbers is inimical to the Trypanosomes, or merely that they are present in flies which for some other reason are physiologically unsuited to the development in them of the Trypanosomes" (Carpenter, pp. 40-41).

In a recent paper R. W. Glaser (1920) has summarized the literature on intracellular non-pathogenic organisms found in insects and states that these are found to occur in Blattidæ, Homoptera, Formicidæ, and certain Lepidoptera and Coleoptera. It would be interesting to ascertain whether similar bacilli occur in bloodsucking flies other than *Glossina* and whether their occurrence or absence bears any relation to the portability of Trypanosomes in such flies. Cross (1917), for example, in the passage we have already quoted comments on the probability that only a percentage of potential carrier-flies are capable of infecting healthy camels with Surra, but no one seems to have noticed whether such intracellular bacteria occur in biting flies in India.

We may now indicate briefly what we consider is required to be done to investigate the question of Surra in India. Assuming that Surra is carried in natural reservoirs which are domesticated or wild animals and that it is transmitted to domesticated animals by biting flies, we require definite knowledge regarding (*a*) the biting flies concerned and (*b*) the normal method of transmission. As regards the biting flies we require a thorough survey of the various species of Tabanidæ and other biting flies which occur throughout the Indian Region. At present our knowledge of the Indian Tabanidæ, to take an example, is extremely scrappy and defective. We know that about 131 species have been described as occurring within Indian limits and these have been placed in about 13 genera, but it is probable that a proper survey would bring the number of species up to nearer two hundred. Even of those we do know, there is extremely little on record regarding their distribution, life histories and bionomics generally. The early stages

of only about a dozen species are known at all and no work has been done on the distinctions of the early stages, although it is important to be able to recognize these as well as the adults. Another line of work which we suggest is a study of the male genitalia in the Indian Tabanidæ; it is certainly the case in some other groups of insects that the females of different species can only be separated with difficulty or not at all, whilst the males are abundantly distinct in structure, and it may be that similar cases occur in the Tabanidæ. A thorough survey of the distribution of the various species, which would of course include especially collections made in Surra areas as well as in adjacent or similar non-surra areas, might well throw some light on the problem of a transmitting agent, if only one species or group of species is concerned in this. A third line of work, which should be carried on *pari passu* with the collection, discrimination, and lifehistory work is that of observation and collection of natural parasites and enemies; we know, for example, that many Tabanids suffer severely from egg-parasites, but we know very little regarding these parasites, their bionomics, discrimination and distribution, and as to how far they could be utilized as natural checks on particular species in any area.

The collection of the flies should be done with the help of tame animals and in collecting from such animals it should be noted what particular parts of the animal are affected by each species of fly. As regards transmission, we are dealing with three or four different organisms, the original host, the fly-carrier, the Trypanosome and the animal to which the flagellate is carried, so that we have a problem which is only partially an entomological one. The first point that requires to be determined is whether transmission under natural (and not purely laboratory) conditions is purely mechanical or whether the trypanosome undergoes a developmental cycle within the fly. This includes a general study of the flagellates occurring in the flies, both larvæ and adults, and is non-entomological. Should likely flagellates be found in the larvæ (and it must be remembered that Tabanid larvæ at least are predaceous and are quite likely to acquire a flagellate fauna from worms and aquatic animals which form their food) we would suggest experiments with bred flies reared from larvæ found in Surra areas. A study of the flagellates would also include a study of these in mammalian, and possibly also in non-mammalian hosts, in Surra and, for comparison, in non-surra areas. To carry out these investigations thoroughly, as they require to be carried out in view of the importance of this disease in India, requires a proper staff of wholetime workers, which should include as a minimum a Veterinary Officer, a Protozoologist and an Entomologist (Dipterist), with appropriate subordinate staff.

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Have any observations been made as to whether Tabanidæ prefer already infected animals to healthy ones ? It is so in the case of other flies.

No ; I am not aware of any such observations.

There is an interesting comparison between " Surra " and " Sleeping sickness." The former has two forms according to Cross. The latter has two forms also of which the first is carried by *Glossina palpalis* and kills slowly and the second is carried by *G. morsitans* and kills quickly. Possibly some of these conflicting observations on Surra are caused by their being really two forms of the parasite, with separate careers.

The general succeptibility of animals is a very difficult matter to judge of.

Does it occur on my side of India ?

It is recorded from Bombay and Kalyan, but I think those were imported cases.

You can at least all help this investigation by sending us in specimens of your local Tabanidæ. We have a large number here but our series of specimens is very incomplete in regard to distribution both in space and time.

With regard to the question of Fly Survey, should this survey be carried out with special reference to Tabanidæ or of biting flies generally ? I think the consensus of opinion points towards Tabanids being the carrying agency, Gunn (*Quarterly Journ. of Vety. Science,* 1887, quoted by Lingard) pointing out for the first time that " Surra " was associated with the presence of collections of water, the disease being specially found in grass-cutters' ponies.

We recommend a general survey of biting flies to start with but I expect that later on it would narrow down to Tabanidæ.

30.—FURTHER NOTES ON THE OCCURRENCE OF COLEOPTERA IN THE HUMAN INTESTINE.

By R. A. SENIOR WHITE, F.E.S., *and* S. K. SEN, B.Sc.

Since the first author published his original note on this subject in the "Indian Journal of Medical Research" (1920) some further cases have been reported.

In the *Journal of the Ceylon Branch of the British Medical Association* the disease is recorded from Jaffna, a sea-board town in the extreme north of Ceylon, thus extending the known distribution to the low country of the whole island, as Matara, from whence came the first recognition of this condition, is similarly situated near the southernmost point of the country.

The case occurred in a child of 4 years, with serious symptoms, and it is indeed suspected that a similar agency was responsible for the deaths in infancy of the 3 elder children of the same parents. Nothing is said as to possible modes of infection, but embryo-like objects with a distinct alimentary canal were seen under a low power in the fæces, which were further notable for their remarkable freedom from ova of the usual intestinal parasites. The sketches of the beetle and the "embryo-like objects" referred to in the article are most unfortunately not reproduced. The beetle is referred to in the title as a "*Rhynchoporus*"! This is presumably meant for *Rhynchophorus* but the behaviour of the beetles on deposition is described as being exactly similar to that of *Onthophagus bifasciatus* as recorded in the original note, and there is little doubt that it is this or a similar Coprine species which is meant. Who is responsible for identification is not stated, and the generic name probably is entirely misapplied. It is likely that the only beetle known by name to the Medical Author is the redpalm weevil (*Rhynchophorus ferrugineus*) and he possibly labours under the delusion that the scientific name of all beetles is "Rhynchoporus."

The same author mentions *en passant* the occurrence of another case at Mihintale, a village near Anuradhapura, from whence the disease was recorded in the original note.

The disease is also recorded from Bengal and in this case the Doctor recording it fortunately forwarded specimens to the second author. The symptoms in the Bengal case were practically the same as those in the cases reported from Ceylon, the insects being voided with the

fæces mostly by children suffering, it would appear, from an obscure form of diarrhœa. So far as known, in Bengal the first report of the occurrence of these beetles in the human intestine was published in the *Indian Medical Gazette*, August 1919, by Mr. A. C. Dey, Medical practitioner at Barhamganj in the district of Faridpur. Subsequently in the April 1920 issue of the same Journal, he again reported their occurrence in the case of a boy of 5 years who did not look so ill, having "2 or 3 stools in the morning" and "the insects flying out of them." The boy had good appetite "his meals consisting of rice, dal, fish and milk." A similar occurrence of these insects was also reported from a village called Kalamridha, about 10 or 12 miles from his place, but the people reporting it failed to produce the beetles. The author remarks that the insects seemed to belong "to the same class as were found in mangoes" in that part of their district. But so far as reported the only two beetle pests of importance attacking mangoes in Bengal are weevils belonging to the genus *Cryptorrhynchus* (*C. gravis* and *C. mangiferæ*). Of the four specimens forwarded by him one was a male and 2 females of the Ceylon species, the fourth being an undetermined species belonging to the same genus (*Onthophagus*).

In the October 1919 issue of the *Indian Medical Gazette* Mr. S. C. Sen, L.M.S., reports having discovered a similar occurrence of these beetles as far back as 1904, a specimen being forwarded to Lieutenant-Colonel Alcock, I.M.S., the then Superintendent, Indian Museum, who described it as "dung-eating Coleoptera." He mentions having come "across a number of such cases, in a village in the district of Khulna, Bengal. The insects resembled those found in local mangoes and they used to fly immediately upon their expulsion from the intestines. Children of both sexes, of 3 to 5 years, were the victims, and the chief symptoms were diarrhœa, griping, and general emaciation." He adds that during the last fifteen years' practice at Saharanpur, he has not come across any such case in the United Provinces. Subsequently in the December issue of the same Journal Mr. T. N. Chakravarti reports three such cases from a place called Hoolarhat in the Bakerganj district (Bengal), the victims in these cases being an adult aged 40 years who had been suffering from "black-water fever" and his two children who were living in the same room and "the insects came out in each case, after the rectal saline injections." He adds that the insects were "of the same quality as already reported" by the other two doctors.

With regard to the possibility of these insects being introduced per anum, such medical opinion as we have consulted thinks that the sphincter muscle is too strong to permit of the entrance of beetles of this size and the theory is further negatived by its now known occurrence

in adults who would never permit of the discomfort caused by the presence of the beetle in this region and are in any case clothed.

In view of the practice, adopted by many children in Bengal, of defœcating on the ground, the second author invites attention to the possibility of the beetles making their way along the excretory meatus while the sphincters are loosened during movements, the beetles gaining a purchase somewhere in the vicinity of the rectum and living on the fœcal matter there and causing irritation of a mild nature, till expelled on some subsequent occasion (not necessarily during the next evacuation, unless their entry is attended with an immediate onset of diarrhœa ; a costive system would be naturally to their advantage). In the absence of experiments on the respiratory requirements of these beetles, the explanation cannot of course be advanced with any degree of certainty. The possibility of their introduction through the mouth in the form of eggs, by the medium of liquid or insufficiently masticated solid food, would indicate the necessity of experiments on the viability of the eggs in the digestive juices.

We have only published this note to draw the attention of medical men to the existence of this disease in India in the hope that they will be on the look out for it, whereby its known distribution may be extended to definite areas. Concerning the etiology of the disease, not being medical men, the validity of the theory of inguinal infection advanced by the second author can only be criticized by doctors. After the discovery of the distribution, a study of the habits and food of the inhabitants of the affected tracts might shed further light on the problem. What is particularly needed is that a watch should be kept for any early stages (larval and pupal) at postmortem examinations.

Were the Bengal specimens all females ?

No ; one was a male.

I have examined the male specimen passed round and think such could be voided without damage to the intestine.

Are you sure the beetles are really passed ?

Mr. Chakrawarti states (*vide* our Note) that they came out after a saline injection.

No larvæ and pupæ have ever been found ?

No.

It seems decidedly suggestive that only adult beetles have been found so far. I can hardly believe that infection takes place by means of eggs ingested with food. Even if eggs were ingested, they would probably be killed in the stomach and, if they succeeded in hatching, it is unlikely that the larvæ could remain and feed and live in the intes-

tine, whilst it is inconceivable to me that the pupal period could be passed in the human interior. It seems much more likely that the beetles themselves effect an entrance through the anus. In this connection it is suggestive that, of seven specimens so far recorded, no less than six are females. If the specimens had bred in the intestine one would expect a more equal distribution of the two sexes. It is also suggestive that this infection has only been noticed in hot and damp areas of the plains, where the bodies of the persons infected are likely to be left at night unprotected by any covering.

Speaking medically, beetles could only crawl up the anus of a person with an anæsthetic injury. The disease appears to be a definite one for which there might be an explanation. I do not understand how the younger stages can exist in the intestine. The larvæ are probably similar to the rest of the genus. Except in a pathological condition fæces would not remain sufficiently long in the intestines for the life-cycle to be completed.

These observations are very interesting from a medical point; but is the disease common or an accidental one? If the former, then the infection probably occurs through eggs taken orally. We want statistics of frequency of occurrence and experiments as to causation.

Could infection occur in the pupal stages? Handfuls of dirty rice are often swallowed.

In Mesopotamia I had a stool sent in containing houseflies, bluebottles, their eggs, and a cockroach, all well preserved and obviously passed quickly. They had all been swallowed probably in dirty water.

Intestinal myiasis has not been well worked out in India. There are two kinds, one accidental and the other specialized.

We have only put forward these remarks to draw the attention of Medical men in India to the occurrence of the disease and to invite their attention to its investigation.

31.—PRELIMINARY OBSERVATIONS ON LETHAL TEMPERATURES FOR THE LARVÆ OF *TROGODERMA KHAPRA*, A PEST OF STORED WHEAT.

(Plates XLI—XLIII).

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In spite of the marvellous achievements of science in its application to human welfare, the problem of the safety of our daily bread still remains unsolved, and the surest method of successful storage of wheat grain awaits discovery.

Taking the damage done by insects to stored wheat at 5 per cent., we find that in 1918 the Punjab alone lost 4,710,062·5 maunds of this valuable foodstuff, or, in other words, paid Rs. 235 *lakhs* as tax to these six-legged creatures. It is therefore imperative for us to fight these insects and save this quantity of wheat, which is sufficient to feed about 1,032,343 people for one year.

In safe storage of grain we are concerned with two distinct problems which require different measures to solve them :—

(*i*) the grain to be stored should be *made* free from all stages of insects, and,

(*ii*) the grain stored should be *kept* free from insects. All the methods employed to achieve these ends can be grouped under two distinct categories.*

A. In the first category we include all those methods which aim at freeing the grain from insects and keeping it free from insects in a single operation. What is claimed for these methods is that all the stages of the insects that may be present either die or leave the grain, and fresh introduction is made impossible either by chemical or mechanical means. Some of the methods that fall under this head are :—

1. *The use of Napthaline balls* :—Grove maintains that all the stages of insects present in the grain are killed by keeping napthaline balls in the grain. This acts as a deterrent and stops further infections (10). This method, however, does not seem to be very effective as the pests are said to appear in spite of this precaution (5).

* Various methods of grain storage that have been in vogue in India are described at length by Fletcher and Ghosh (*Report of the Third Entomological Meeting held at Pusa 1919,* Vol. II, pp., 725-733).

2. *The use of Castor and other oils* :—It is believed that castor oil, if rubbed on the grain, ensures its safety from insect attack. This requires confirmation, as it is also stated that it does not render wheat immune to insect attack (1, 5). Moreover, castor oil is said to retard germination (5).

3. *The use of Mercury* :—In some parts of India mercury is used to keep grain free from insect attack. A few drops of it are put in an excavated soap nut, or in any other receptacle, and kept in the grain. Its vapours are supposed to kill all the stages of the insects. In small jars it is said to prevent increase of beetles, but in the case of large bins its effect is not so marked (12).

4. *Mixing sand with grain* or covering the top of grain with a uniform layer of sand a few inches thick. Mixing sand with grain is generally practised in some parts of India and is known to give good results in cases where grain is to be dealt with on a small scale (19). Covering the top of the grain with a layer of sand may be effective and practicable in the laboratory in bottles, jars, and small bins, but on a large scale its practicability seems doubtful and its efficacy has not yet been tried. At any rate the application of this method cannot be recommended for large elevators. In the first place the amount of sand required for an elevator, where arrangements for storing over a *lakh of maunds* of wheat are made, will be very great and will increase the weight of the contents of the bins so much as to necessitate a considerable reduction in the total amount of wheat stored. Secondly, the main object of the elevator is to clean the wheat before it is stored and pouring in sand will nullify this object and the grain will have to be recleaned before it is sold. This will mean extra expense and inconvenience. Moreover, out of almost 6,000 *maunds* stored in a bin, the whole quantity cannot be disposed of at once, and this will mean establishing a layer of sand at the top every time the grain is taken out. Again, the use of sand, in cases where the grain is already infected, is objectionable, as the sand gets into the injured parts of the grain, and the flour made from such grain is not eatable.

For this method it is claimed that the adults and such larvæ as are capable of doing so leave the grain and crawl out of sand and cannot get back. No fresh attack is possible because sand acts as a barrier to insects getting into the store.

5. *Hermetical sealing of grain* :—Dendy (4) has performed some experiments on the methods of air-tight storage for preserving grain against insect attack. The results of his experiments on a laboratory scale are very hopeful, but so far this method has not been tried on a commercial scale. For this method it is claimed that insects already

in the grain are killed and in bins which are air-tight, there is no possibility of fresh infection. This method, if found successful, will be the simplest and the best for grain storage.

B. In the second category we include all those processes in which the grain is first subjected to treatments which make it free from all stages of insects. It is then stored in insect-proof stores. In cases of re-infestation the grain has to be treated again to kill the pests. The methods that come under this head are those that are commonly employed at the present time and particularly where large quantities of grain are to be handled.

1. *Fumigation* :—Fumigation is a process which is very commonly resorted to for freeing grain from all insects attacking it and also to kill all stages of insects in a store (6, 13). The gases that are commonly used are carbon bisulphide, hydrocyanic, acid gas and sulphur dioxide. Chlorpicrin, which is said to give good results, is not obtainable here.

This method is very expensive and full of risks under Indian conditions (1, 9). The two gases that can be used easily are carbon bisulphide and hydrocyanic acid gas; the former is highly explosive and latter is a deadly poison.

Moreover, this method is not quite reliable. During 1920 we tried experiments with these two gases. At Hansi, a small godown was fumigated with a full dose of hydrocyanic acid gas, which had no bad effect on the larvæ and adults of *Trogoderma khapra*. We only succeeded in killing a number of mice. Again at Hoshiarpur we tried full doses of carbon bisulphide and hydrocyanic acid gas to fumigate juar seed that was stored in a room in the *mandi*, but without killing the insects. Fletcher also mentions this method as unsuitable for India (5).

2. *Mechanical blowing off of the insects* :—In the elevator at Lyallpur as well as in the elevators at other places this method of cleaning the grain is resorted to. It may be effective in removing the adults, but the fact that the wheat in the elevator was attacked the very first time it was stored showed that this operation does not remove the eggs, larvæ and such pupæ as pupate inside the grain (1).

3. *Superheating* :—By this method all the stages of insects attacking the grain are killed and the grain thus cleaned is stored in insect-proof bins. It is chiefly with this method that the present paper deals.

From the above it will appear that so far no really satisfactory method, which may be recommended generally, has been discovered. "There is no treatment known that can immunize the grain against the insects even for a few months." (5, p. 756). Barnes and Grove after a series of experiments came to the conclusion that the damage from wheat

pests was an inevitable evil and suggested the cumbersome mechanical method of cleaning the grain by sieves and hand-winnows (1).

Some of the methods mentioned above are quite reliable so far as the destruction of insects is concerned, but are liable to effect the germinating capacity of the grain, while others, which might be effective in the laboratory, are not such as can be applied on a large scale, for example at the elevator at Lyallpur.

The elevator at Lyallpur is a huge building about 60 feet high and consists of 32 bins, having a total capacity for storing 100,240 *maunds* of wheat (for particulars of these bins see the plan and the table attached).

The bins are of three types (*i*) Hexagonal bins, which are the biggest. There are sixteen bins of this type. (*ii*) Quarter bins. Each of these bins is a quarter of the hexagonal bins of the first type. There are ten bins of this type. (*iii*) Rectangular bins, which are the smallest of all, each being rectangular in outline. Of this shape there are six bins.

Each of the 32 bins is about 50 feet deep with a small manhole at the top for running in the grain and a conical outlet at the bottom for running out the grain.

Plan of bins at the elevator, Lyallpur, showing the shape and arrangement of bins in transverse section. (See Plate XLI, fig. 2).

Table showing the exact dimensions, grain capacity, etc., of the bins.

No. of bins.	Total depth of each bin.	Depth of bottom cone.	Volume of each bin in cubic feet.	Capacity of each bin for wheat.		REMARKS.
	Feet.	Feet.		Mds.	Srs.	
1 to 16	49½	5½	11,338·33	5,823	13	In bins No. 1, 2, 3, 4, 8, 11, 15, 16, maximum wheat to be stored is 106·85 tons or 2,938 mds. 4 srs.
17 to 26	49½	5½	2,834·58	1,455	33¼	
27 to 32	49½	5½	2,600·88	1,265	0	

During 1920 the elevator was used for the first time and after a few months complaints of insect attack were received and accordingly the Entomological Section was asked to deal with the problem. It was found that the insects infesting the wheat were *Trogoderma khapra* at the top and *Rhizopertha dominica* at the bottom of the bins. The temperature records of the bins showed that the temperature in those

bins which were filled with wheat rose as high as 113° F. and was always a few degrees higher than that of the empty bins. It was also found that this high temperature did not affect adversely the insect life in the bins. This fact is very remarkable, because Bradwell in *Proceedings Hawaii Entomological Society* (Vol. III, pp. 506-509) states that 110° F. kept long enough to penetrate the tissues of the insects will kill insect pests of the stored grain.

The two main features of the problems at the elevator are :—

1. That the grain was infected before it was brought to the elevator last year and that the method of cleaning the grain by air-blast was not effective in removing all the stages of the insects attacking it.

2. That the construction of the bins is such that they can easily be rendered insect-proof.

Therefore the problem of safe storage in the elevator reduces itself to this—the grain to be stored should be free from all stages of insects *before* it is run into the bins or should be rendered free from insects *after* it has been stored in the bins.

Fumigation of a bin containing 6,000 maunds of wheat with carbon bisulphide or hydrocyanic acid gas is full of risks. Moreover for any of these gases to penetrate all through the column of wheat, 50 feet deep and about 17 feet in diameter, we should allow more than 48 hours exposure. The escape of the gas will also be a slow process and even if the manhole at the top of the bin is opened, the gas will take a long time completely to get out of the entire bin. Thus a greater part of the grain would be surrounded by a poisonous atmosphere for over 4 days : an interval in which carbon bisulphide is definitely known to affect the germinating capacity of wheat. The cost of this operation will be Rs. 63 for carbon bisulphide at the rate of Re. 1-4 per lb., and about Rs. 35 for hydrocyanic acid gas per bin.

On the other hand if some simple process of killing the insects in the wheat, that is brought in, could be discovered, and the wheat cleaned of insects before it is stored, the problem will be much simplified.

Superheating is thought to be the best, safest and cheapest, and it is possible to plan out an arrangement for heating the grain before it is run into the bins. The germinating capacity of the grain is not at all impaired at the temperature at which insects die (see Table III attached).

Temperature has a direct influence on insect metabolism and with its rise their activities increase till an optimum is reached. A few degrees above this limit however imperils their life. "At 30° C to 40° C (86° to 104° F.) the insects are very active, especially the adults. This activity increases with the increase in temperature, until the insects

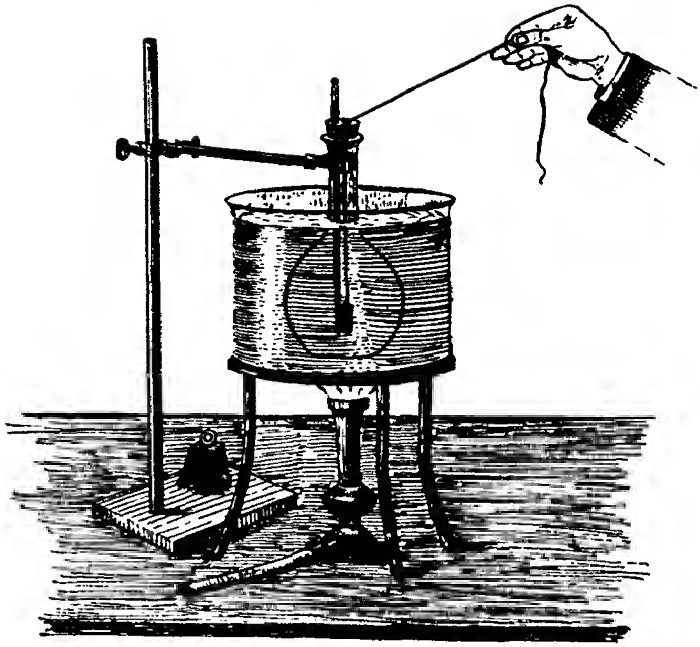

Fig. 1.—Apparatus used for determining lethal temperatures.

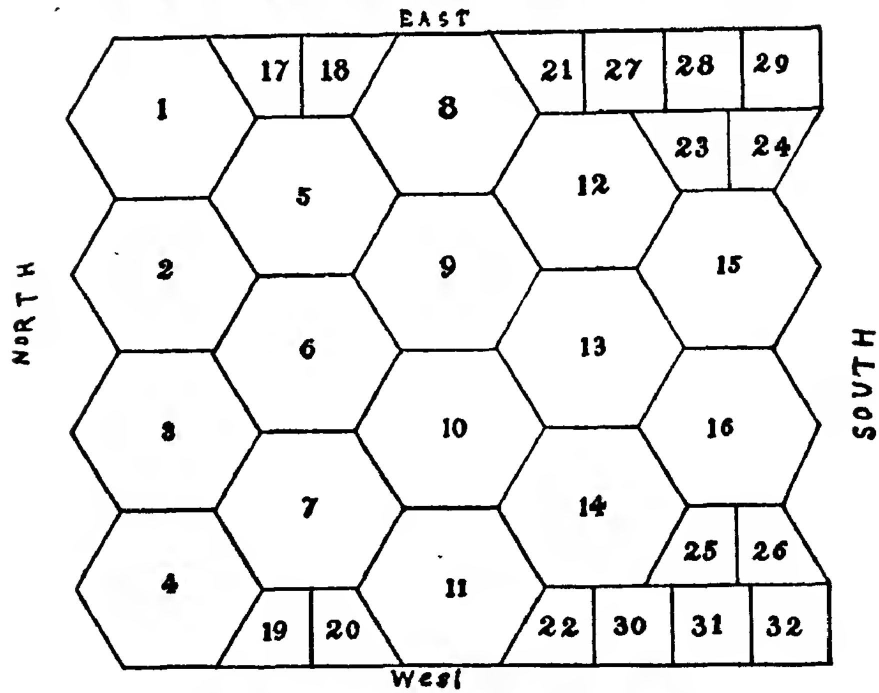

Fig. 2.—Plan of Wheat Elevator at Lyallpur.

become frantic in their efforts to escape. High temperatures cause sudden death" (8). Even such high temperatures as are within the limits of atmospheric changes are known to effect insects adversely, and it is on record that in France in 1911 a single day of excessive heat was enough to kill off all the rose aphids (2).

The methods of killing insects by subjecting them to higher temperatures is not new to us. It has been practised in India from very remote times. "Spreading wheat in the sun and stirring it occasionally is said to make the weevils leave it." (3, 16). And this practice is common even to-day. Infested grain if it is spread in the sun at 115° or 116° F for two hours kills off most weevils (20).

Artificial heat is coming into use for the purpose of dealing with the insects of the stored products, and superheating in mills and godowns has come into general practice in some countries (7, 8, 11, 17, 19). As to the temperature which is fatal to these insects there is very great divergence of opinion. Some investigators put it at as low a figure as 110° F., while others put it at as high a point as 145° F. Thompson says that weevils cannot stand a temperature of 119° F. for more than 2 to 3 minutes (20). Schribaux maintains that weevils are killed in 2 minutes at 122° F. (18). Lefroy, at a lecture delivered at the Royal Institution, on the destruction of grain insects by heat, said that a temperature of 145° F. applied for 3 minutes killed every insect pest of the grain. This variation is probably due to the varying conditions under which the different investigators have worked. It seems likely that insects of the tropics get used to higher temperatures and can stand excessive heat much better than their fellow-beings of the cooler regions. It has been stated that 110° F. maintained long enough to penetrate the tissues of the body kills insect pests of grain, but in the elevator at Lyallpur the temperatures in the bins went as high as 113° F. during summer and still the insects were breeding quite well.

In view of the above considerations, experiments were started on the larvæ of *Trogoderma khapra*, the commonest pest of wheat in the Punjab, in order to discover the lethal temperatures of the stored grain pests. This insect was selected for our experiments, because its larvæ are known to be the most resistant of all the stages of its life-history to the severities of temperature and can live for a long time without food.

The following simple apparatus was used in our experiments.

A large flask of 2,400 C. C. capacity was used to get an atmosphere of the desired temperature. This was heated on a water-bath (Plate XLI, fig. 1). The flask was fitted with a cork with two holes, through one of these a thermometer was introduced and through the other hole,

which was larger, the larvæ were introduced into the flask by means of a small wire-gauze basket, suspended by a cotton thread. The level to which this basket was lowered was the same as that of the bulb of the thermometer and the temperature recorded by the thermometer therefore represented the temperature to which larvæ were subjected.

When the basket with the larvæ was introduced into the flask, the temperature dropped a little but remained fairly constant after that. The larvæ were taken out after remaining in a known temperature for a definite time and kept at room temperature for at least 24 hours to see if any survived. In some cases the larvæ as a result of imperfect penetration of heat, became motionless, but revived after 24 hours. So that all the larvæ treated one day were examined after 24 hours. For temperatures above 90° C. a sand-bath was used and for temperature below 60° C. an incubator was employed.

Over 500 observations were recorded; for every temperature the experiments were repeated twice or three times and oftener for the critical temperature. For each experiment 10 larvæ were taken. The results of our investigations are given in Tables I and II, and graphically represented in the form of a curve. (Plates XLII, XLIII).

TABLE II.

Table showing Lethal Temperatures for the Larvæ of T. khapra, *in Relation to the time of Exposure.*

No.	Temperature (Centigrade).	Period of Exposure.	Their appearance on removal to room temperature.	Effect of heat on larvæ 24 hours after removal to room temperature.
1	100-85°	30 seconds .	Motionless .	Dead.
2	84-78°	45 ,, .	,, .	,,
3	77-71°	60 ,, .	,, .	,,
4	70-69°	90 ,, .	,, .	,,
5	68-63°	120 ,, .	,, .	,,
6	62-61°	180 ,, .	,, .	,,
7	60-59°	240 ,, .	,, .	,,
8	58°	300 ,, .	,, .	,,
9	57°	360 ,, .	,, .	,,
10	56°	420 ,, ..	,, .	,,
11	55°	600 ,, .	,, .	,,
12	54°	20 minutes .	,, .	,,
13	53°	30 ,, .	,, .	,,
14	52°	90 ,, .	,, .	,,
15	51-50°	5 hours .	,, .	,,

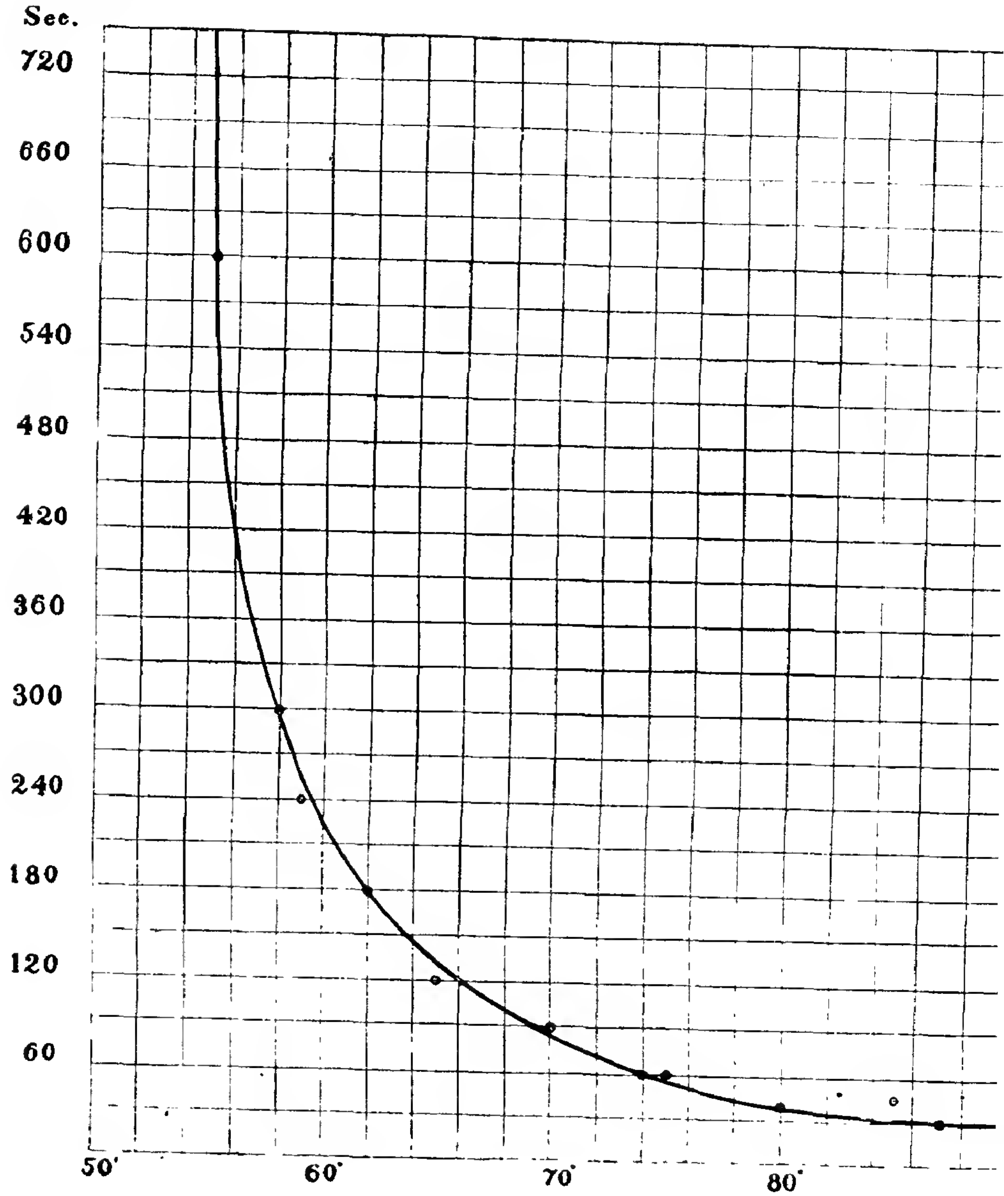

FIGURE 2

SHOWING LETHAL TEMPERATURES FOR *T. KHAPRA* (LARVAE)

Table III.

Table showing the effect of high temperature on the germinating capacity of different types of wheat.

No.	Temperature centigrade.	Time of Exposure.	Percentage of germination.	Type of wheat.	Remarks.
1	168°	2½ hours	*Nil*	IV	
2	120°	3 ,,	,,	II	
3	105°-110°	1½ ,,	,,	VI	
4	100°-110°	3½ ,,	,,	III	
5	105°	15 minutes	97%	III	
6	105°	15 ,,	60%	XXIII	
7	105°	15 ,,	100%	VIII	
8	105°	15 ,,	95%	II	
9	100°	1 hour	*Nil*	XX	
10	100°	1 ,,	*Nil*	X	
11	100°	1 ,,	*Nil*	XXII	
12	100°	1 ,,	*Nil*	XV	
13	100°	1 ,,	70%	V	
14	100°	1 ,,	*Nil*	XVII	
15	100°	1 ,,	*Nil*	VII	
16	100°	20 minutes	90%	XIV	
17	100°	20 ,,	100%	XXII	
18	100°	15 ,,	100%	XVIII	
19	100°	15 ,,	100%	XIX	
20	100°	15 ,,	100%	IX	
21	100°	15 ,,	100%	XXI	
22	95°	15 ,,	100%	VIII	
23	95°	15 ,,	100%	VII	
24	75-78°	1 hour	100%	XVI	

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32.—*ANATRACHYNTIS FALCATELLA*, STT. (*PYRODERCES SPODOCTHA*, MEYR.).

(Plate XLIV).

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

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Anatrachyntis falcatella. Proc. Second Entl. Meeting, 1917, p. 114.
Anatrachyntis falcatella. Proc. Third Entl. Meeting, 1919, p. 149.
Anatrachyntis falcatella, Meyr., Exotic Micro., I, 325, 1915.
Anatrachyntis falcatella. Fletcher, Ind. Agric. Ent. Mem., VI, 99 (Jan. 1921).

The moth has hitherto been recorded as a rubbish feeder and has been recorded from :—

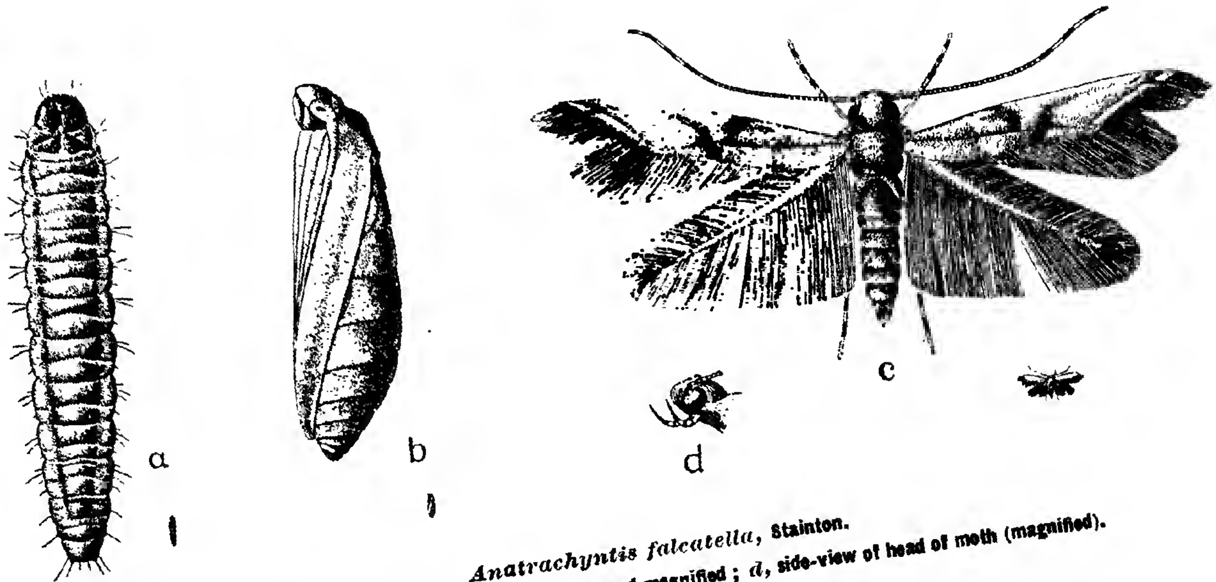
Pusa....1913, 1914, 1916. From cotton, cotton buds, in cage containing *Dactylopius* sp., from *Eublemma* cage and on Lac.
Calcutta.
Shillong....October 1916.
Gobichettipalayam (Coimbatore District) on a rotten pomegranate.
Kandy....Larva in resinous masses of lac coccid *Tachardia albizziæ.*
Bangalore....January 1920. Larva in broodlac on *Shorea talura.*

Last year when I began the study of the parasites and the predators of lac, my attention was drawn to a consignment of broodlac on *Shorea talura* received from Dr. Gilbert Fowler of the Indian Institute of Science, Bangalore. The first moth emerged on the 22nd September 1920 and a number of moths continued to emerge until the 24th October and for some time thereafter. Two other consignments were received subsequently and the number of moths that emerged from these was also large. The fourth consignment has been received only recently and from this too the moths have begun to come out. The large number of moths that emerged from the four consignments made it highly suspicious that the caterpillars were not altogether harmless, and from the observations that I have been able to make hitherto, it appears that the caterpillar feeds on the healthy lac females within resinous cells. The caterpillars occur in healthy broodlac along with *Eublemma*

amabilis, but the two predators could be distinguished readily from their method of affecting the resinous cells containing gravid females. In the four consignments of broodlac received from Bangalore the number of *Anatrachyntis falcatella* was far in excess of *Eublemma amabilis* and it is fortunate that it is so. *Eublemma amabilis* is a serious pest in Northern India, and it will require patience and perseverence to limit the ravages of this serious pest. In some places I have seen it so bad, that the crop is extremely poor and the emergence of larvæ is late and poor. The pest has remained unchecked so long, that the depredations committed by it have resulted in unsettling the market and causing unwarranted fluctuations. The lac-growers and the manufacturers, who are not entomologists, cannot understand the situation. They generally ascribe the poorness of the crop to climatic and such other conditions. No doubt these are important factors and cannot be easily overlooked, but the state of affairs now warrants a critical study of the parasites and predators which bring about such a state of affairs. When such a study is undertaken it will be found that the parasites and the predators of the lac insect are factors not to be overlooked in any scheme of expansion of the industry. When this stage will be reached, I think further steps will be taken to obtain accurate data regarding distribution and damage brought about by each predator. It will then, I think, be necessary to restrict the distribution of each predator within its own sphere of its activity. *Eublemma amabilis*, so far as I have been able to consult the literature, and so far as my own experience goes, is mostly destructive to Lac in Northern India. By this I do not wish to create a false impression that it does not occur in South India. From occasional consignments received from Southern India, as well as those from Banganapalle, it is apparent that *Eublemma amabilis* does occur there but not to such an extent as it occurs in the North. *Anatrachyntis falcatella* has not been reported damaging lac from Northern India. There is only one record and that too from Pusa, on the 22nd July 1913. Thereafter no moth has been either captured or reared from broodlac either on *Ber* or *Palas* at Pusa. In the Pusa collection the majority of the specimens have been from cotton either from buds, dry shoots affected either by the Bollworms, *Earias fabia*, *E. insulana*, *Alcides leopardus*, *Phycita infusella*, *Phenacoccus hirsutus* or *Ph. corymbatus*. It has been reared at Kandy (Ceylon) from larva in resinous masses of lac coccis, *Tachardia albizziæ*. (*Bombay Journal*, XVI, 607 ; 1905).

In the specimens of broodlac on *Shorea talura* from Bangalore hitherto examined by me both the predators, *Eublemma amabilis* and *Anatrachyntis falcatella*, have been found working side by side on the same

PLATE XLIV



Anatrachyntis falcatella, Stainton.

a, larva ; *b*, pupa ; *c*, moth, natural sizes and magnified ; *d*, side-view of head of moth (magnified).

broodlac sticks. The latter were far in excess of the former. Both affect the gravid females and destroy them. *Eublemma amabilis* caterpillars work from the side as well as from the top side of the resinous cells enclosing lac females on the branches. *Anatrachyntis falcatella* caterpillars prefer to work mostly from the sides of the resinous cells. The caterpillar gnaws a hole at the side of a resinous cell and penetrates into the resinous incrustation. The passage of *Eublemma* caterpillars could be easily detected by following the tunnel filled with flat, oval, discs of resin mixed with body juices of their victims. In some cases the resinous cells are completely hollow and are filled with dark crimson, flat, ovalish discs. The cocoon of the caterpillar consists of whitish silken threads glued together with deep crimson, flat oval discs. Prior to pupation the *Eublemma* caterpillar makes a hole of exit, closes it up with whitish silken threads and pupates immediately below it.

The *Anatrachyntis falcatella* caterpillars also make their way inside the resinous intrustation by gnawing bits of resin and then attacking the females. The bits of frass left by these caterpillars in the tunnels made by them are different from those of the *Eublemma* caterpillars. In this case the granules of resin are small and round, quite unlike those of *Eublemma* caterpillars. Both resinous and other granules consisting of chitin, dye and other visceral portions from the body of the lac females lie about the tunnels made by the caterpillars.

The full-fed caterpillar is light crimson of much the same colour as the lac females, and as such is quite distinct from *Eublemma* caterpillars which are white or whitish crimson. It is 5·75 mm. long, and a little over 1 mm. broad. It is light to bright pinkish in colour on account of its meal of the lac females. The head is jet black, with small whitish porrect hairs. The mandibles are jet black in keeping with the general colour of the head, and are powerful. There is a shiny black thoracic shield with an obsolete indentation in the middle. The meso and meta-thoracic segments are concolorous with the abdominal segments which are light pinkish with white setæ on them. The anal and the penultimate segments have a chitinous shield of a light fuscous brown colour with whitish hair pointing caudad. There is a fine transparent, longitudinal line from the first abdominal segment to the anal end through which the pulsation of the heart could be seen under high magnification. (Plate XLIV, fig. *a*).

From what I have been able to observe hitherto, it appears that the caterpillar in its attempts to reach the dead and dry female lac cells bites its way through the living female cells as well and thereby causes death. In one case, a caterpillar was seen to enter the resinous incrustation on a *Shorea talura* stick from the side and within three

days it had penetrated a length of 20 mm. when it began to pupate. It had thus killed off seven healthy lac females. The caterpillar, when full-fed, spins a thin, whitish cocoon. Prior to pupation it makes a circular hole on the resinous incrustation which it lines with a thin, silken webbing. Such holes of exit for the adult moth could be easily seen under the binocular with a little practice. If disturbed, it moves about and spins a fresh cocoon either within or between crevices of coalescing resinous cells. In the majority of cases examined, the pupa lies within the resinous incrustations, in a thin silken cocoon. The pupa, when taken out of the cocoon, is brick brown in colour with a slight bloom. It is 3 mm. long and a little over 1 mm. broad, the two black spots on the head representing the eyes. The three pairs of legs are folded on the sternum, the apices of the antennæ reach the apices of the anterior wings which lie closely adpressed laterally. Dorsally the head is pointed anteriorly and broad posteriorly. The mesothoracic segment is the most prominent, nearly twice as long as pro- and metathoraces together. Eleven abdominal segments are distinct. There are a few short white hairs at the anal end. (Plate XLIV, fig. *b*).

The adult moth is pale brown. When resting on lac-covered sticks it rests at an angle, the anterior part of the body being slightly raised. The moths are not very brisk fliers. They have hitherto been observed to be quiet during the greater part of the day. (Plate XLIV, fig. *c*).

The addition of this moth to the list of predators on the lac insect increases the difficulties of cultivation. The lac insects have already a host of predators and parasites to contend with. It is just possible that this moth, in course of time, may divert its attention from cotton to lac and it will then be time to adopt rigorous measures to combat it ; when the question of the establishment of nurseries for the distribution of broodlac is mooted it will be advisable to keep an eye on this, as well as other, predators.

33.—DETERMINATION OF EMERGENCE OF LARVÆ FROM EXAMINATION OF THE OVARIES OF LAC INSECTS.

(Plate XLV.)

By C. S. MISRA, B.A., *First Assistant to the Imperial Entomologist*

In the past much difficulty has been experienced in fixing the local dates of emergence of the lac insects. These dates, as is well known to those who are interested either in the cultivation or the manufacture of shellac, vary from place to place. In some cases the variation in the dates of emergence is so great that considerable difficulty is experienced in starting and finishing the work of inoculation in proper time and this has, in my opinion, militated to a great extent against the extension of lac cultivation. Had it been easy to foretell or to know with some certainty the dates of emergence of larvæ, the cultivation of lac, in my opinion, would have been more extended and varied than what it is now and the heavy fluctuations which are the order of the day would not have taken place so frequently as is the case now. No doubt there are other and more important factors, which have a direct bearing on the production of lac, but this is also one of them, and as such, demands some attention. In the past the lac-growers have had to depend mostly upon their own past experiences or on the advice of the elders within the lac cultivating zone or villages. They have no definite data whereon to base their calculations and results, and it is no wonder that these calculations are extremely vague and unreliable. In the same locality or lac-growing zone, I have seldom come across two lac-growers agreeing with each other in their calculations regarding the probable date of emergence of the lac larvæ. The variations, when they do occur in such tracts or localities, produce no serious consequences, but now with the impetus that the industry has received of late, the cultivation is bound to increase not only in the localities which hold the monopoly of lac cultivation at the present time but in new and distant localities where the host plants of the various species of the lac insect occur in abundance, and signs at present are not wanting to show that the future augurs well and has great potentialities for the development and consolidation of the industry provided adequate precautions are taken to safeguard it. I have repeatedly drawn the attention of the public and of those interested in lac cultivation and manufacture to the necessity of regarding the present boom as extremely detrimental to the industry unless full advantage is taken of the present inflated prices

in taking active and permanent steps to reorganize it in the light of experiences gained at the present time. But if nothing is done and the occasion is allowed to slip by, the industry is expected to receive a set-back. What the effect will be, the future alone would show. But to my mind it appears that the present lethargic state of the growers and manufacturers is bound to redound prejudicially on the well being of one of the most ancient and most important industry which is mostly cottage and rural in its nature and which provides means of livelihood to millions of the country's poor and ignorant, who inhabit the outskirts of forest or are denizens of extremely backward tracts where the present influences seldom, if ever, penetrate. The truth of this casual remark will be apparent from a case I found in the remotest corner of the Chhota Nagpur Plateau. Years before the present boom in prices took place the cultivator used to get Rs. 5 per maund of stick-lac and this was at a time when the market quotation for T. N. was between Rs. 30-35 per maund. The year I visited the locality, T. N. was quoted in the Calcutta market at Rs. 235 a maund, but the poor ignorant cultivator was paid only Rs. 5 a maund of 52 seers. Some time after, when the same cultivator chanced to visit a relative of his in the suburbs of a *Hat*, he came to know that something extraordinary was happening in the shellac market and decided to obtain better terms from the local *Paikar* when he came to him next for the sale of his produce. I was subsequently informed that when the *Paikar* did turn up, the cultivator demanded better terms and was given an increase of rupee one over what he was paid before. In fact the cultivator should have got at the rate of Rs. 80 a maund of 82 lbs. Such and other causes militate against the extension of cultivation and are the causes which make the shellac trade and the market so very uncertain when few care to gamble away their savings and their fortunes. Had the cultivator been paid Rs. 80 or at the least Rs. 50 a maund, he would have got an additional impetus to increase his cultivation and the result of such accumulated extensions would have been that considerable large quantities of the crude stuff would have been brought to the market for sale. But the things, as is usually the case, move very slowly and nothing tangible seems to result from the past years of inflated prices. The compiler of the District Gazetteer, Palamau, on pages 116-117, remarks in much the same vein as given by me above. He says :—

"..............Recently there has been a boom in lac, which has done much to save the old Zemindar families, their income being in some cases more than doubled. Incidentally the result has been that landlords now claim that lac trees, exclusive of planted trees and trees on household land, are their property, the claim being apparently based

on the analogy of the Government Estate, where lac trees, even on cultivated land, have been assessed to rent................. "

These and such other considerations led me to find out some means whereby the emergence of lac insects could be determined with at least some degree of certainty. This step is essential in any scheme of extension of the industry and I may say here, that others before me have felt the necessity of finding out methods whereby the wastage of lac larvæ, that is inevitable these days, could be appreciably, if not totally, avoided. A writer early in the seventies remarked :—

" The failures that have attended the attempts to send seed-twigs from one part of India to another, have been due mainly to the fact that the seed twigs were cut too long before the swarming period or too near it."

In places where the cultivation has been started for the first time there have been instances where through sheer ignorance the attempts have proved entirely unsuccessful owing to the subordinates having mistaken the exclusion of the males for the emergence of the lac larvæ. Almost all the lac-bearing branches were removed and carted, when it was detected at the last moment that a serious mistake was made. There are not only straggling records of such happenings but there is ample evidence to show that such occurrences are not uncommon in the lac-growing tracts even at the present time. No doubt, the ignorance and illiteracy of the masses is a serious obstacle to the adoption of new and improved scientific methods but, as in other spheres of life, where the cultivator becomes aware of some personal gain to follow by the adoption or relinquishment of a practice, it is expected that he will soon be convinced of the necessity of adoption of a better method for prognosticating the emergence of lac larvæ in his own plantation or in those of his neighbours. Some of the experienced Forest Officers too have felt the necessity of adopting a method which would do away with the uncertainty and fickleness in the emergence of the lac larvæ. Mr. McKee, (*Indian Forester*, Vol. I, p. 269, 1876), said :—

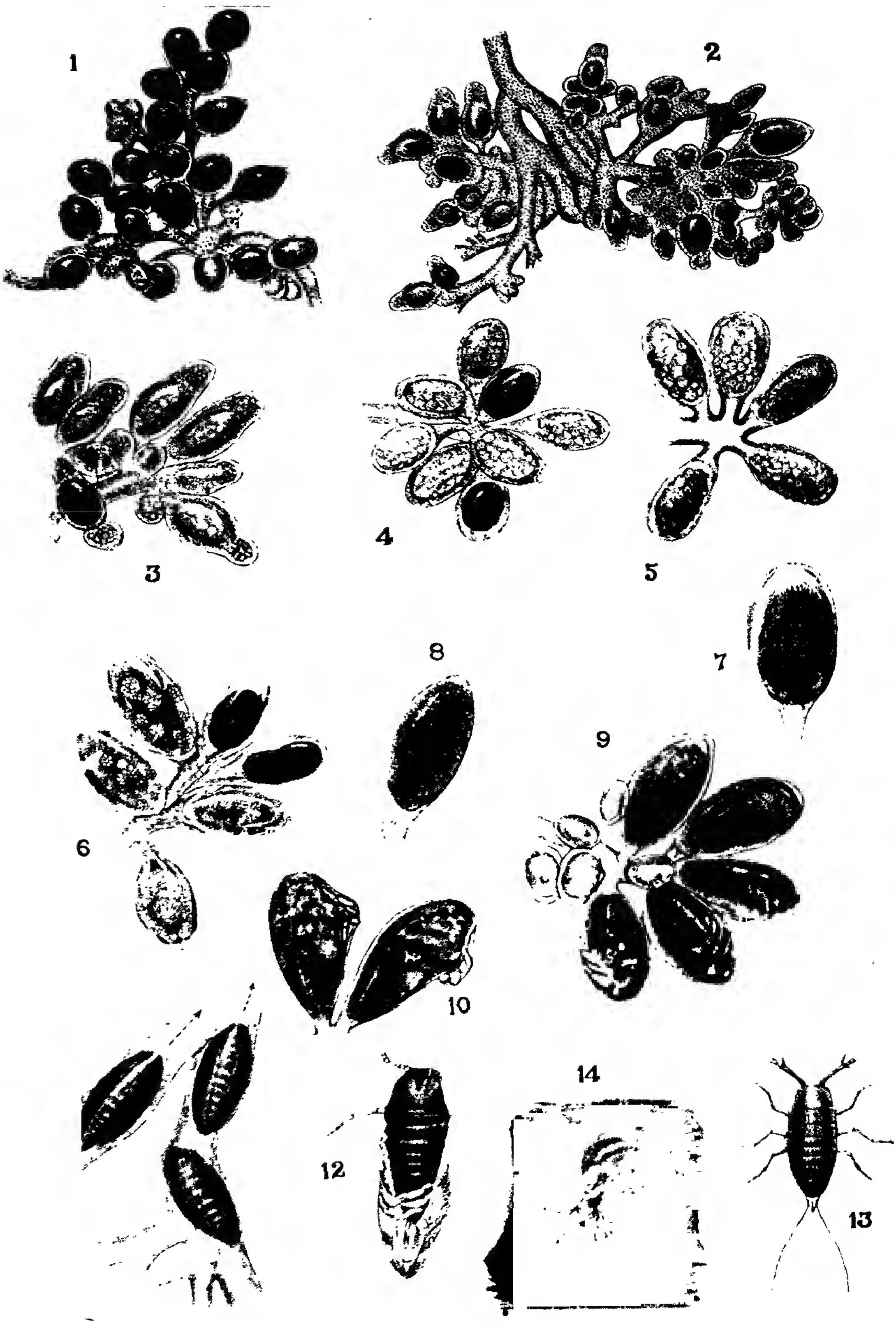
" ....The next point to fix on is the local date on which the insects leave the parent cells, a step of great importance and one on which the first success of the plantation will very greatly depend ; should the work of gathering broodlac be delayed until visual proof of the exit of larvæ is obtained, a vast quantity will be killed in the operation of collection, transport and of tying the incrusted twigs on the standard selected nurseries."

Later on the same officer remarked :—

" ....A knowledge of which will enable a larger number of trees to be prepared during the working season than if it was necessary to delay the operations until evolution actually took place, as owing to the latter being barely simultaneous in and about one locality, the period for forming the plantation must be necessarily limited to the number of days it takes the cells to become empty, besides which, by attaching the lac twigs before the birth of larvæ great numbers are saved, which would otherwise perish during the process of being attached to the trees.............. "

In short, those who are doing the cultivation or those who are interested in shellac manufacture or those who are anxious to develop the dormant resources of their Estates or property to the full, are really anxious to know of a definite and reliable method to fix the emergence of the lac larvæ in their own particular tracts. No doubt there are methods by which the experienced lac growers approximately determine for themselves the probable date of emergence of lac larvæ. But as I have already said above, such rough and ready methods of determination could hardly be relied upon, especially when the cultivation has been started in an altogether new locality or is contemplated to be started in a new one.

The necessity of knowing the date of emergence of larvæ is intimately connected with the cultivation of lac. In one year, 1915-16, the total export of shellac from the port of Calcutta only was 96 million pounds. To produce this, nearly 240 million pounds of stick-lac must have been utilized. The value of this produce at the then market rate of Rs. 15 per maund of 80 lbs., amounts to 45 million rupees. If we take the average normal produce of a cultivator to be represented by 160 lbs., then the amount realized by a cultivator comes up to about Rs. 30. This sum is quite sufficient for a cultivator to pay off his rental dues, etc., and to utilize the produce of his land for the maintenance of his family and himself. During the war and especially after it, the rates of shellac as well as stick-lac went up very high, and the result was the lac cultivators were able to obtain remunerative prices for their stick-lac. Some of them were able to pay off their debts and to get back their lands which were mortgaged for years previously. Others were able to buy more land and to put it under lac producing trees. Thus with the impetus that the industry has received of late, it is probable that more localities will be opened up for lac cultivation and in consequence more broodlac will be required to meet the growing demand. This will necessitate somewhat more accurate determination of the



DETERMINATION OF EMERGENCE OF LAC LARVÆ.

EXPLANATION OF PLATE XLV.

Determination of emergence of Lac Larvæ.

Fig. 1. Ovules in process of development. (The dark coloured ones are un-healthy.)

" 2. A portion of the ovary showing further development of ovules.

" 3. A portion of the ovary showing development of the ovules.

" 4. A portion of the ovary showing development of healthy ovules as well as the presence of unhealthy ones, 26 days before the emergence of larvæ.

" 5. Ovules—22 days before the emergence of larvæ.

" 6. Ovules—18 days before the emergence of larvæ.

" 7. A single ovule highly magnified, 13 days before the emergence of larvæ.

" 8. Ovules—10 days before the emergence of larvæ.

" 9. Embryos—6 to 12 days before the emergence of larvæ.

" 10. Embryos—5 days before the emergence of larvæ.

" 11. Revolution of the embryos with the ovarian branches.

" 12. Partial emergence of a larva.

" 13. A newly-hatched larva (dorsal view).

" 14. A fully ripe female testis showing external characteristics.

emergence of lac larvæ so as to facilitate cutting and transportation of broodlac long distances either by rail, post or steamer.

The method advocated herein is not final, and it is possible that other workers in the field would be able to suggest some other more simple method than the one detailed here. But for the time being, an examination of the ovaries would give sufficient data wherewith to know the probable date of the emergence of larvæ. I have tried this method personally for some years past, and find it gives sufficiently accurate data wherewith to fix the emergence of the larvæ in distant parts of the country. In the past I have examined broodlac for the emergence of larvæ from Sind, Baroda, Assam, Banganapalle, Karauli and Rewah, and found this method sufficiently indicative of fixing the dates of emergence with greater degree of certainty than would have been the case otherwise.

The accessories required for this work are :—

A compound miscroscope.
A dissecting microscope or a Greenough's Binocular.
A few clean slides.
A scalpel.
Two or three pipettes (one medium, one fine).
Three or four stout mounted needles.
Three or four watch glasses.
Distilled water.

The only difficulty that is likely to be experienced by most of the growers is that they cannot provide themselves with the equipment given above. The microscope and the dissecting microscope or the binocular require a very heavy outlay, far beyond the reach of an ordinary grower. But the method advocated above is more or less a laboratory method intended for those who have some knowledge of microscopic technique or are working in a laboratory fitted with the above things. All that is required is to take a few cells on a stick, remove the resin round the insects either with a scalpel or a teaser, make a longitudinal incision with a pointed needle, and take out a portion of the ovaries, on a clean slide. The specimens are then washed either in normal saline solution or in distilled water, adjusted under the binocular and examined under the microscope. A comparison is then made with the figures in the accompanying plate, and the period determined for the particular locality from which the specimens have either been obtained or collected.

In Mysore *A. falcatella* is very rare. *Eublemma* is our worst pest. There is no systematic cultivation of lac in Mysore.

I had occasion to work at lac for a couple of months with Mr. Howlett in connexion with certain suggestions made by the Shellac Committee. The lac-insects obtained from different host plants are all called by the general name of *T. lacca*. Is there sufficient structural difference amongst them to warrant any specific differentiation and are the host-plants interchangeable ?

We hope to be able to say by the next Meeting.

The title of Mr. Misra's paper was misleading. I hoped to learn the technique employed. Fortunately Mr. Howlett's views on the lac problem have been preserved and will be published shortly in a Forest Bulletin.

34.—THE PROPORTION OF THE FEMALE FORMS OF *PAPILIO POLYTES*, L., IN DEHRA DUN, UNITED PROVINCES, AND BIHAR.

By EDWARD B. POULTON, D.Sc., F.R.S., *Fellow of Jesus College, Oxford, and Hope Professor of Zoology in the University.*

The little paper on the proportion of the female forms of *Papilio polytes*, L., read and kindly emphasized by Mr. T. Bainbrigge Fletcher at the Third Entomological Meeting at Pusa, in February 1919 (Report, Vol. III, pp. 903-906) has produced a most interesting series of *polytes* captured in 1919 and 1920 by Mr. C. M. Inglis at Baghownie, Laheria Sarai P. O., B. & N.-W. Ry., towards the south of the Darbhanga District of Bihar. I therefore take the opportunity of contributing a preliminary study of this material to the Fourth Entomological Meeting at Pusa. Furthermore, a fine series captured by Mr. O. C. Ollenbach at Dehra Dun, United Provinces, in March 1917, only reached me after the Third Entomological Meeting had taken place, the captor wisely deciding to avoid any unnecessary risks in transport. This series also has been studied and the results are submitted together with those from Baghownie.

Mr. Inglis' captures were all made within two miles of Baghownie and all were taken and sent, whether damaged or not. The injured specimens are of great interest being in nearly all cases symmetrically shorn, or torn at the anal angle of the hind wing, injuries evidently the work of birds or lizards. In a few cases as much as half one or both hind wings has been shorn away. In addition to the *romulus* forms recorded in the table on page 261, Mr. Inglis captured it on July 31, 1917, and September 2nd and 9th, 1918. Concerning the models he wrote on February 9th, 1920 :—

" *hector* itself is never caught. *P. aristolochiæ* is of course, a common species here. The earliest I have noticed appears to be May 29th, but it is not till the middle of July that they can be said to be common. August also seems to be the month during which most are got, the same as *polytes*."

Also on July 10, 1920:—

' Mr. Bainbrigge Fletcher writes. 'I should think we are roughly 400-500 miles beyond the range of *Papilio hector*. The elevation at Pusa is about 150 feet above sea-level.' These words would also apply to this place which is not very far from Pusa. We are evidently a little closer to the *hector* range than Dehra Dun and the *romulus* form is slightly stronger here " (see the table on page 261).

Concerning the Dehra Dun series Mr. Ollenbach wrote in September 17th, 1919:—

" I made no choice but took all that came, so far as I was able to. The *romulus* form is certainly very uncommon here and *P. hector* does not occur. The nearest parts of its range are about 800 miles to the East and the same distance to the South. *P. aristolochiæ* is plentiful here now, though some twenty years ago it was not to be seen."

On this last interesting point he wrote again on March 10th, 1920:—

" I cannot quite remember when *P. aristolochiæ* first appeared in Dehra Dun, but probably about twenty-five years ago. I have a specimen in my collection taken in the year 1895. They had probably only just appeared at that time and were very scarce, although now they are just the reverse; *aristolochiæ* is however by no means so numerous as *polytes*, which is a very common species."

In 1920 Mr. Ollenbach, was unable to continue to collect *polytes* in Dehra Dun because " for some unknown reason this butterfly and *P. aristolochiæ* were very scarce although in ordinary seasons they were very common."

In the following tabular statement I have classified the *polytes* females in four groups according to the absence or presence, and degree of development, of the white spot in the hind wing cell. The transition between *stichius*, with no white in the cell, and *polytes*, possessing it, is complete—so much so that all those specimens in the fourth column of the table and some of those in the fifth would, unless carefully examined, be placed in the third as typical examples of *stichius*. The white mark in the cell of such individuals is only represented by scattered scales often less than a dozen in number. The comparisons which formed the basis of the table were made upon the under-surface of the wings only but it is not anticipated that an examination of the upper-surface would lead to any change.

Dates in 1919, 1920 at Baghownie, Bihar.	Males.	Male-like *cyrus*.	Female form polytes (including stichius) mimicking Papilio aristolochiæ.				Female form *romulus* mimicking *Papilio hector*.
			No white in H. W. cell *stichius*.	Minute trace of white in H. W. cell.	Small white spot in H. W. cell.	White spot in H. W. cell large to moderate.	
1919, July . .	7	1	2	0	2	3	2
,, August . .	23	5	6	3	3	3	0
,, September .	7	3	6	0	1	3	1
,, October. .	9	2	6	1	2	0	0
1920, March . .	5	0	1	0	0	0	0
,, April . .	4	1	0	0	4	1	0
,, June . .	4	0	1	0	1	0	0
,, July . .	11	7	8	1	4	12	0
,, August . .	4	0	6	2	7	4	1
October. .	31	10	8	2	11	6	1 (seen)
TOTAL .	105	29	44	9	45	32	5
	Total 124, including 4 additional females.						
In 1917 at Dehra Dun, United Provinces.	The above total from Baghownie, S. Darbhanga District, Bihar, to be compared with those below, from Dehra Dun, United Provinces.						
1917, September .	149	38	15	0	10	10	1
	Total 35 females of form *polytes*.						

In addition to the specimens tabulated above, three females of the *polytes* form were taken at Baghownie in August and October 1919 and October 1920, respectively but all so much injured in both hind wings that they could not be assigned to their proper columns. A fourth female of the same form would have appeared in the fifth column but for the accidental omission of data. It arrived in a consignment containing specimens taken from March to July 1920. The following additional males were also taken :—4-12 November 1919, 4 ; 10th May 1919, 1 ; 1 November 1920, 2.

A few additional specimens were taken at Dehra Dun in the years 1917 to 1919, the most interesting being a *romulus* female on 11 September 1919.

Comparing the two localities by the aid of the figures in the table the chief difference is to be found in the proportions of the male-like female form *cyrus*, outnumbering the *polytes* form at Dehra Dun, but less than a quarter of the same form at Baghownie. This difference would be somewhat diminished but would remain great if we allow for the fact that more males were taken at Dehra Dun and make the reason-

able assumption that more *cyrus* would have been taken with an increased number of males at Baghownie. The true proportions can only be ascertained, as Mr. Fryer has rightly maintained, by breeding from indiscriminately collected larvæ and it would be deeply interesting to check the results shown in the above table in the manner. I sincerely hope that this may be possible in both localities.

The great difference between the proportions of the *cyrus* and *polytes* female forms in the two localities may probably be explained by the absence, until recent years, of the *aristolochiæ* models at Dehra Dun and by similar reasoning we may expect a gradual increase in the proportions of the *polytes* f., now that the model has become common there.

The other exceedingly interesting difference, already referred to by Mr. C. M. Inglis (p. 260), is in the proportions of the *romulus* f., to be doubtless explained, on the lines suggested by him, as the result of the much greater distance of Dehra Dun from the range of the model *P. hector*.

I trust that an attempt will be made to breed from one of those rare female forms at both localities. The following considerations make it almost certain that the great majority of them are heterozygotes (hybrids) bearing the pattern of the dominant, and the most probable mating will have been with a male bearing the *polytes* or *cyrus* tendencies (both recessive to *romulus*). The commonest result to be expected would therefore be approximately half *romulus* females (heterozygotes) and half *polytes* females (recessives), or half *romulus* and half *cyrus*.

The reason why the rare *romulus* forms are likely to be heterozygotes is as follows: The handing on of the mimetic pattern from a region where it and its model are common, is probably brought about by wandering males, although sometimes by regular seasonal or exceptional migrations. When a male bearing the tendency of *romulus* thus reaches a population in which the *romulus* female is rare or absent it will rarely or never pair with such a female but with *polytes* or *cyrus*, or the *polytes*-like heterozygotes combining the two. In each case the offspring will be heterozygotes, the females bearing the appearance of *romulus*, the survivors of these again will generally pair with males bearing the common recessive female patterns, yielding again half heterozygotes and half recessives. And even when the rare heterozygotes *romulus* female meets and mates with the equally rare male and produces offspring of which a quarter are pure dominant *romulus*, the survivors of this will at once tend to mate with the common male, yielding again heterzygotes bearing the *romulus* pattern. Therefore,

in areas far removed from the range of *hector* where *romulus* is abundant such rare *romulus* forms as are found will be nearly always heterozygotes and only very rarely pure dominants.

The above reasoning was applied to the more complex case of *Papilio dardanus*, in Africa and was subsequently confirmed by breeding experiments in many parts of the range where rare female forms were found to behave as heterozygotes (*Proc. Ent. Soc. London,* 1914, pp. LXVIII—LXX).

The proportion of the *stichius* form to the true *polytes* females does not differ greatly in the two localities ; for the 9 Baghownie examples on the 4th column are *very nearly stichius* and, unless carefully examined, would be assigned to this form. It will be interesting to study in a similar manner the development of the chief hind-wing markings of *aristolochiæ* in various localities and determine whether there is any correspondence in this respect between it and mimetic *polytes*. That this is not unlikely is shewn by the strong development of this marking of both model and mimic in Ceylon, where the *stichius* form is excessively rare (*Rep. Proc. 3rd Ent. Meeting, Pusa,* 1919, p. 904).

Another point of great interest brought out by a careful comparison of the *polytes* females from both localities is the existence of a small proportion of individuals with the hind-wing pattern intermediate between that of *polytes* and *romulus*. The proportion of these in localities where *romulus* is commoner would be well worth studying. It is probable that such individuals are heterozygotes exhibiting imperfect dominance, but this suggestion can only be tested by breeding.

The further investigation of this interesting example of female mimicry will, I think, be assisted by bringing together all the significant references to *polytes* and its models in the publications of the Bombay Natural History Society. I owe these to the kind help of Mr. C. M. Inglis and Dr. R. Hanitsch. In the critical remarks on some of the references I have been kindly helped by Dr. Karl Jordan. A few observations from other publications or hitherto unrecorded have been added.

The references are arranged according to the localities starting from the South of India, proceeding northward and then eastward into Burma and China. References which mention only volume and date are all from the *Journal of the Bombay Natural History Society*.

The following early reference to this example of mimicry occurs in a paper by Colonel Charles Swinhoe (Vol. II, 1887, p. 173) :—" *P. pammon* (*polytes*) the female of which mimics two species, *P. diphilus* and *P. hector*, and in the Nicobars the female of the variety *nicobarus* mimics the Nicobar variety of *P. diphilus*, called *P.* (*aristolochiæ*) *camorta*." *P. diphilus*, Gray is a synonym of *aristolochiæ*, F. Rothschild

considers that *nikobarus*, Feld., cannot be separated from the Indian *polytes*. (*Nov. Zool.*, Vol. II, 1895, p. 347). It is however retained as a sub-species by Jordan (Seitz, *Oriental Papilionidæ*, p. 61), who states that "the female form similar to the male appears to be commoner than in other districts."

The range of *Papilio hector*, L., is given by Rothschild (*ibid*, p. 234) as "Ceylon, S. India, Madras, Central Provinces, Calcutta." In Ceylon and Southern India it "is very common at low elevations ; farther north it becomes rarer, and does not seem to go beyond the 25th degree of N. Lat." Jordan also states that it is "recorded from Chittagong on the north-east side of the Bay of Bengal" (Seitz, *ibid*, p. 34).

The range of the *romulus* female of *polytes*, mimicking *hector*, is thus defined by Rothschild (p. 347) "Ceylon, South India, Bengal, and occasionally in Sikkim." Jordan gives it as "Ceylon to North India ; in Sikkim, where *hector* does not occur, *romulus* is scarce and further east it has not yet been observed at all...." (Seitz, *ibid*, p. 61). The facts recorded in the earlier pages of this memoir prove that *romulus* occurs in small numbers very far east of Sikkim.

The localities now start from the South of India, as already explained. The records published in *Proc. 3rd. Ent. Meeting, Pusa*, 1919, (pp. 904, 905) should be taken into account together with those in the earlier part of the present paper.

Palni Hills. Captain W. H. Evans, (Vol. XX, 1910, p. 384—

"74. *Papilio polytes*. Common at low and often seen at high elevations probably all the year."

"70. *Papilio hector*.
"71. *Papilio aristolochiæ*. } Common at low elevations; May, June, August to October ; *hector* is often seen at the highest elevations."

Bangalore. K. Kunhi Kannan. (Vol. XXI, 1911, p. 699) says that the species is trimorphic in Bangalore.

Bangalore District. T. H. L. Grosvenor. (*Ent. Record*, 1920, p. 201.).

P. hector is "abundant everywhere,...... apparently continuously brooded, as from March to December they were always to be found in every possible condition. This was the only *Papilio* I found of which both sexes were commonly taken......at the approach of dusk they settle for the night usually in small colonies of 5 or 6, and apparently return to the same tree each evening. I watched one for over a fortnight, having selected it for observation on account of a crippled hindwing, so that there was no chance of mistaking it. One

afternoon I. saw this insect at the farther side of the plantation at least a mile away but it came back to its usual tree for the night ...." *P. aristolochiæ,* Mr. Grosvenor noted, was "not nearly so abundant in the Bangalore district as *P. hector*, but in the Central Provinces it is in great numbers, and there replaces *P. hector*." *P. polytes*: "Perhaps the most general and abundant species of the Indian *Papilios*. The male is to be seen everywhere, but the interesting polymorphic female is very difficult to find, as it seldom if ever flies in the open, and has to be searched for in dense bushes, and when found is generally torn to rags." All three forms of female were taken, and......" The prevailing form is that resembling *aristolochiae*." Concerning the likeness to the models the author remarks. "It is difficult to see what advantage is gained by mimicry, as the habits of *polytes, hector* and *aristolochiæ* are entirely different, and one never has the slightest doubt as to which species one sees, although so closely resembling one another in colour and markings. It certainly does not protect *polytes*, as I have on several occasions seen the King Crow (*Dicrurus ater*) not only attack, but eat it."

The author in writing his last quoted sentence seems to have forgotten the fact that *all* species, protected or unprotected, have their enemies, and that *complete immunity* only existed in the mind of Erich Haase and never in nature. Nevertheless I agree with the author in believing that the ordinarily accepted interpretation of mimicry in *P. polytes* is erroneous, and it seems worth while to reprint here a Statement I wrote several years ago for a journal now out of print (" *Bedrock*," Vol. II, No. 3, Oct., 1913, pp. 310-312) :—

"How can we account for the evolution of two mimetic forms in a butterfly which remains dominant when its models are absent or excessively rare ? It is worth while to consider this question in some little detail, for I believe that the true explanation is different from that usually given.

"*Papilio polytes* is an unusually dominant and successful swallow tail. Its rate of reproduction, combined with a probable measure of distastefulness advertised by a conspicuous pattern, its powers of flight, alertness, and other adaptations of many kinds, keep up the large average numbers in spite of the attacks of enemies of all sorts in all the stages of its life-history. The large numbers that survive in every generation will of course, include the fittest, and so the high level of protection efficiency is maintained. This is the condition of *polytes* in the Hong Kong and Macao districts where the single model (*aristolochiæ*) is so rare that it is unreasonable to suppose that it exerts any effect, and

this was doubtless its condition before the evolution of the mimetic forms. There is no reason to suppose that the surviving percentage of *polytes* was increased by the presence of the *aristolochiæ* model or during the growth of the mimetic likeness. All that happened was this :—Certain variations formerly unselected, now tend to fall into the surviving percentage, and, once started, the further stages of transformation were effected in the same way. Each change that suggested still more strongly an advertisement common to a far more distasteful form would tend to be selected. So too, when *polytes* spreads beyond the range of *aristolochiæ*, or when the model for some reason disappears from an area in which *polytes* is abundant, the constitution, not the amount, of the surviving percentage is changed. The mimetic pattern soon disappears, although the species that bore it remains as abundant as before. The survival or extinction of the species is not affected : all that has happened is the survival or extinction of a pattern borne by a certain proportion of the individuals of the species. When these disappear other individuals with another pattern take their place. It is, furthermore, extremely probable that selection is reversed when the models are absent, for a female that resembles the male is better advertised than one which resembles a non-existent model. Although I believe that many mimicking species bear the above-described relationship to their models, I do not mean to imply that this is always so. No doubt there are plenty of mimicking species which depend upon the presence of the model for their existence and could not live in areas from which the model disappeared."

I should perhaps, add that we can well understand the advantage of a mimetic pattern, even when accompanied by great differences in flight and behaviour, if we look upon it as an aid to memory of enemies, helping them to recall an unpleasant experience, rather than as the deceptive resemblance of a palatable eagerly sought-for species to one unpalatable and avoided. Furthermore the difference in flight means for *polytes* powers of escape from those enemies which would devour it but not its model.

North Kanara District. J. Davidson, T. R. Bell and E. H. Aitken. (Vol. X, 1895-97, p. 580). "*P. polytes* : This is very common and very destructive to orange and lime trees in gardens......"

The Konkan. E. H. Aitken and E. Comber. (Vol. XV, 1903-04, p. 52) "*Papilio pammon*, L. Quite common all over the district. Of the several forms of females the *polytes* type, which resembles *P. aristolochiæ*, is the commonest and the *romulus* type is not rare, but we have no record of the form that is similar to the male."

The Konkan. G. W. V. de Rhe-Philippe. (Vol. XVIII, 1907-08. p. 884) "*Papilio polytes* L. I have to record a fourth type of female intermediate between the "*romulus*" and "*polytes*" types. It has the discal markings on the hind wing *white* as in the 'polytes' form, but at the same time approaching the '*romulus*' type in having the broad white band on the forewing. The specimen, which was taken at Khandala in October 1905, is the only one of the kind I have seen."

Bombay Presidency. E. H. Aitken. (Vol. II, 1887, p. 36). "*P. pammon.* This is nearly as abundant as the last (viz., *P. erithonius*), the *polyctor* form of the female being decidedly the most common." Dr. Jordan agrees with me in concluding that "*polyctor*" was inadvertently written instead of "*polytes*."

Nimar District, Central Provinces. D. O. Witt. (Vol. XIX, 1909-10, p. 569).

Papilio polytes, L. "More common in forest areas than in gardens and cultivated land. Of a skulking habit, keeping usually to forest with bushy undergrowth in it. Rains and cold weather."

Central Provinces. J. A. B. (*i.e.*, Betham). Vol. VI, 1891, p. 329.) "113. *Papilio polytes,* L. This and *P. pammon* are one and the same species. It is the common black and white "swallow-tail" to be found almost everywhere..........It has 3 forms of female, the first almost exactly resembles the male; the second is a mimic of *P. aristolochiæ,* and the third imitates *P. hector*————."

Plains of India. T. R. Bell. (Vol. XIX, 1909-10, p. 33).

Refers to *P. polytes* imitating *P. hector* and *P. aristolochiæ.*

Plains of India. T. R. Bell. (Vol. XXI, 1911, pp. 527 and 531).

(p. 527). "83. *Papilio polytes.* A polymorphic form. The male varies slightly but is fairly constant throughout its range; the female generally with two forms, in Southern India with three, strikingly different in appearance" (with detailed description and plates).

(p. 531). "Another extraordinary thing is that where local forms of *P. aristolochiæ* occur, there the *polytes* form is also modified in a more or less similar way. Things go even further than that in Celebes where typical *polytes* males do not exist, being replaced by a constant similar but aberrant race called *P. polytes alcindor,* Oberth., ; the female is only of one type and that imitates a butterfly of the *P. hector* group called *P. polyphontes,* Boisd, which is only found in Celebes and some few neighbouring islands of the Gilolo group; and this although *P. aristolochiæ* exists there. Why? It is difficult to even guess at an answer."

Dr. Jordan kindly informs me that, although *aristolochiæ* was recorded from Celebes by the Hon'ble W. Rothschild (*Iris,* 1892), the single male on which the conclusion was based came in reality from Bali,

Doherty having erroneously included some specimens from this island in his Celebes collection. No *aristolochiæ* is known from Celebes. *P. polyphontes* is very common there.

Lucknow District. Geo. W. V. de Rhe-Philippe. (Vol. XIV, 1902-03, p. 492).

"81. *Papilio polytes,* L. Common all over the district, especially around lime trees on which the caterpillar (which is very like that of *P. erithonius*) feeds. The species is on the wing throughout the rains and cold weather, the males, as a rule, appearing somewhat later than the females. Of the three forms of the latter, type I, which is like the male, does not apparently occur in the district ; at any rate I have never seen it. Type II, which mimics *P. aristolochiæ,* is common and the only one generally taken ; while type III, mimicking *P. hector,* is very rare, but as I have seen it on two occasions, apparently does occur. Its appearance at all is rather surprising as its model is never, as far as I know, found in Upper India."

Fatehgarh. H. D. Peile. (Vol. XX, 1911, p. 874).

"22. *Papilio polytes*—Common '*cyrus*' form, two males taken. One '*romulus*' female taken, another seen" ; *cyrus* is the male-like female form. If the two specimens were males the correct name would be *polytes.*

Kumaon. F. Hannyngton, I.C.S. (Vol. XX, 1910, p. 361).

"168. *Papilio polytes,* L. Common up to 5,000 feet, May-November. I have not yet come across the *sakontala* form while the *romulus* form of the female seems to occur only in the Terai." By *sakontala* the author almost certainly means the male-like *cyrus* female form, *P. sakontala* being similar to the male *polytes.*

Masuri and neighbouring Regions. Philip W. Mackinnon, and Lionel de Niceville. (Vol. XI, 1897-98, p. 593).

"258. *Papilio* (*Laertias*) *polytes,* L. Very common in the low valleys near Mussoorie from April to October and in the Dun almost throughout the year. The females are of three forms."

Sikkim. Lord Rothschild. (*Novitates Zoologicæ,* Vol. II, 1895. p. 347).

Refers to "Two speciments (of the *romulus* f.) in the Möller collection from Sikkim, one of which has the white of the forewings much less conspicuously marked and comes in the colour of these wings indeed close to certain specimens of female f. *polytes* ; in the same example the red spot in the cell of the hind-wings is tinged with orange."

Darjiling District. C. M. Inglis (in a letter of 1st November 1920 to Prof. Poulton).

In the Darjiling district at Riang, elevation 2,000 feet, the following were taken by Mr. Shaw and seen and noted down by Mr. C. M. Inglis : males 5 ; *cyrus* female 1 ; *polytes* female 2 ; *romulus* female 1. Also at Mangpu, 3,860 feet :—males 2 ; *cyrus* 1 ; *polytes* 1.

Naga Hills. Major H. C. Tytler. (Vol. XXI, 1911, p. 589).

" 205. *Papilio polytes*, L. Common at the foot of the hills throughout the year and a few at 4,000 feet in July and August ; the female form *cyrus* Fabr., is decidedly rare."

" 194. *P. aristolochiæ*, Fabr. A few specimens taken at the foot of the hills in July and August and December."

Chin-Lushai expedition, 1889-90. E. Y. Watson. (Vol. VI, 1891, p. 53).

Papilio polytes, L. Pank, September ; Pokoko, October ; Pank to Tilin, November ; Tilin, December to May.

North Chin Hills and Upper Chindwin District. E. Y. Watson. (Vol. X, 1895-97, p. 672).

243. *Papilio* (*Laertias*) *polytes*, L. Common, but not noticed above 3,500 feet.

Tharrawaddy and the Pegu Yoma. E. V. Ellis. (Vol. XXV, 1917, p. 111).

" 118. *P. polytes romulus*, Cr. Common, but I have only found the *polytes* form of female as yet.

" 112. *P. aristolochiæ*, Fabr. The race *goniopettis*, Roth., is common every where, and it is the commonest *Papilio of* the district." *P. aristolochiæ goniopettis*, Rothsch., is the geographical race inhabiting Burma, Tenasserim and Siam northward to Hong Kong (*Nov. Zool.* XV, 1908, p. 167).

Tavoy. O. C. Ollenbach (in a letter of September 1919, to Prof. Poulton).

" Last February I visited Tavoy in Burma and while collecting for a few days I saw plenty of *P. polytes*, but no example of the *romulus* female."

This last observation was confirmed on 10th March 1920, when Mr. Ollenbach wrote, on his return from a collecting tour in the Tavoy district, " I took note of *P. polytes* and found only two kinds of female, the male-like and the *polytes* forms ; *romulus* was not seen."

Amoy. L. de Niceville. (Vol. XIII, 1900-01, p. 703).

" Of Insects, the butterflies were represented by one forlorn *P. polytes*, L., a damaged *P. clytia*,........"

35.—NOTE ON OVIPOSITION OF *GYNACANTHA BAINBRIGGEI** (ODONATA).

(Plate XLVI).

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.

All the species, of which we have at least ten in India, of the genus *Gynacantha* are evening-flying dragonflies, appearing on the wing about sunset and hawking swiftly until dark, but resting by day in shady places. There seems to be nothing on record regarding their early stages and it is therefore satisfactory to discover some information in the case of one species, especially as its habits seem decidedly abnormal for a dragonfly.

Whilst at Margherita, in Assam, in May 1920, I noticed several specimens of *Gynacantha bainbriggei* on the wing at sunset, hovering close over the ground at the foot of a *Lantana* bush which was growing alongside a small culvert passing under a road which crossed a small *nala* through a Tea Estate. My first impression was that this hole was a resting place in which they took shelter during the daytime ; so I examined it in the morning, expecting to disturb some *Gynacantha* out of it, but it proved to be empty. Examination of the hole showed that above its entrance was a vertical bank of clayey soil, at most slightly moist, and on this bank grew a thick *Lantana* bush, whilst the entrance of the culvert was hidden by long weeds and grass until I cleared these away and revealed the entrance. On returning to the place the same evening, about three-quarters of an hour before sunset and after having seen *Gynacantha* on the wing, I disturbed from the hole two specimens, both of which appeared to be females. Later, watching by the hole, I saw several females enter the gap in the weeds and settle on the vertical bank of earth, when they felt the earth all around with the tips of their abdomens, evidently ovipositing in the earth. Sometimes, when a female was thus engaged, another specimen, presumably a male, would be dashing backwards and forwards in front of the gap, as if waiting for the female to emerge. In one case I watched a female change her position on the bank four times, each time feeling and thrusting with her abdomen. On this evening (18th May) I caught four females actually engaged in ovipositing in this small patch of soil, besides two other

* *Note.*—At the time of reading this paper, the species referred to was ascribed to *G. hyalina* and it is so called on Plate XLVI. Major Fraser, however, has since redetermined the insect as *G. bainbriggei*.—T.B.F.

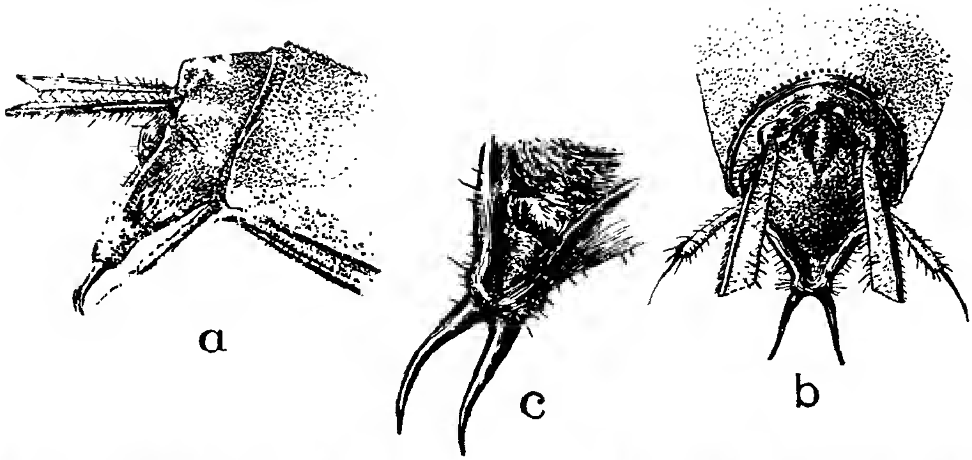


Fig. 1.—*a*, lateral and *b*, terminal view of anal segments of adult female, and *c*, more highly magnified view of digging implement.

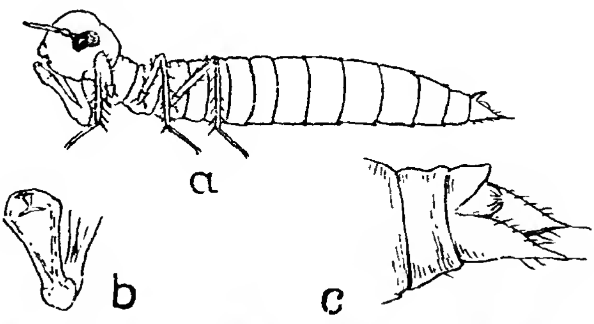


Fig. 2.—*a*, newly-hatched larva, magnified; *b*, mask, and *c*, anal segments, more highly magnified.

Gynacantha bainbriggei.

females and three males which were flying round, and could have caught more, but was interested in observing this curious habit of oviposition.

The next morning I returned to the place and removed some of the soil from the bank where the females were seen ovipositing. On examination of a small sample four eggs were found, but it was impossible to determine how they had been laid, as the earth broke up in removing it. The eggs sank when placed in water. The rest of the earth was placed in water and by the same evening a young larva was found to have hatched out.

It should be added that there was no water in this culvert and there can only be water here when it rains, and the nearest standing water was distant over one hundred yards.

From the strong spine of the female ovipositor one would have expected the eggs to have been thrust inside the stems of plants, but the spine is a digging implement in this case and it is noticeable that it is generally found broken in the case of females caught on the wing.

Dr. N. Annandale has informed me that he found another Æshnine dragonfly (*Aeshna ornithocephala*, MacLach.) ovipositing in earth at the edge of a lake in the Darjiling District. In the case of the Australian *Petalura gigantea* also, Tillyard has described the female as ovipositing when settled on or near the ground at the edge of a mass of decaying vegetable mud in which the larva is found to make regular tunnels. In the case of *Gynacantha* it is probable that the eggs are hatched by the first rain (it will be noted that the larva emerged after a few hours when the egg was placed in water) and the young larvæ washed down into the nearest permanent accumulation of water.

This was a most interesting find, a dragon-fly laying eggs in dry earth. They usually lay in water or in water plants.

In the case of the dragon-fly referred to by Mr. Fletcher as mentioned to him by Dr. Annandale as ovipositing in earth in the Darjiling district, there was a marked difference in habit, which may have been accidental. The lake in question is a permanent, fairly deep one, and the larvæ when hatched could crawl down into the lake. The earth where the eggs were laid was quite moist. This dragon-fly is a day-flier and was noticed in the morning, but belongs to the same group as Mr. Fletcher's species.

36.—NOTE ON THE LIFE-HISTORY OF *CULICOIDES OXYSTOMA*, WITH SOME REMARKS ON THE EARLY STAGES OF *CERATOPOGON*.

(Plate XLVII).

By P. G. PATEL.

The Ceratopogoninæ are, except the sand flies (*Phlebotomus*), the smallest of all blood-sucking Diptera. From the latter they can be readily distinguished by their habit of carrying the wings flat on the abdomen, whereas *Phlebotomus* rests with the wings characteristically raised. Further, on being disturbed, *Phlebotomus* indulges only in short flights, whereas Ceratopogoninæ take to wing in the usual fashion.

Several genera of Ceratopogoninæ are known from India. Of these *Culicoides* and *Ceratopogon* (to a lesser extent) are the most important as regards their attacks on vertebrates. Such flies are known in the vernacular as " *Machhri* " (Bombay) and " *Eutki* " (Assam and Bengal).

To the naked eye the flies of these genera appear as minute black or brown coloured insects which on closer observation with the help of a lens are seen to have a pair of slender long antennæ, biting proboscis projected vertically and with palpi as long as the proboscis. The wings in repose are seen well projected beyond the tip of the body and folded one above the other like a pair of scissors. Wings are often clad with minute hairs or spotted with brown or yellowish markings.

Culicoides and *Ceratopogon* are so similar in appearance that it is often very difficult to distinguish them. Noticeable points of difference between the flies of these two genera are as follows :—

(1) In *Culicoides* the legs are sharply accuminate and in *Ceratapogon* they are comparatively thicker.

(2) The antennæ also afford a good clue in certain cases. As a rule antennæ in *Ceratopogon* are comparatively shorter and the first seven or eight antennal joints are globular while in some cases of *Culicoides* seen by me the antennæ are comparatively more slender and longer and the first seven or eight joints are sub-globular or oblong, specially in females.

(3) Meta-tarsal joints are often equal or shorter than the second tarsal joint in *Ceratopogon*, while in *Culicoides* they are always longer than the second joint.

Apart from these external features flies of both these genera have their own breeding and biting habits. All the known species of *Culi-*

coides as a rule derive their maintenance from the warm-blooded animals including man, whereas flies belonging to *Ceratopogon*, so far as is known, prefer to bite cold-blooded animals such as caterpillars, snails, earthworms, spiders, lizards, etc. The breeding habits of *Ceratopogon* are rather complex owing to their choice for oviposition of a variety of situations such as kitchen refuse, various sorts of fungus growth, algal growths, under fallen damp leaves, bark of trees, rotten fruits, etc.

A number of *Ceratopogon* species are purely terrestrial, *i.e.*, they breed in moist earth, while a few are purely aquatic, and breed both in running and preferably in still water. So far all the species of *Culicoides* known to me have been found to breed in water only.

The terrestrial larvæ of *Ceratopogon* are characterised by being sparsely covered with strong spines all over the body. In some cases each of these spines is again broken up into minute hair-like processes like those of *Phlebotomus*. In general appearance they look like a small caterpillar with a pair of legs on the ventral surface of prothorax and a pair at the anal segment.

The aquatic or semi-aquatic larvæ of *Ceratopogon* are legless, serpent-like in appearance and have a close resemblance to the larvæ of *Culicoides*. All the known species of *Culicoides* larvæ have a characteristic rapid vibratile motion while those of aquatic *Ceratopogon* larvæ are un-alert and very sluggish in their movement.

I will now give a short account of the life-history of one species of *Culicoides*. About a dozen species of *Culicoides* have been recorded from India up to now, of which the life-history of only one species is partly known. There is great difficulty in the identification of these minute flies for want of any reference regarding their bionomics in India and this paper is intended to throw some light on the early stages of one of the species, *Culicoides oxystoma*, Kieff., which is somewhat bigger than other known species of the genus.

Broadly speaking, *Culicoides oxystoma* looks dark-coloured from a distance, but under high power the thorax, antennæ, and legs are seen to be brownish yellow. The extremity of the femora, tibiæ and tarsi lighter. Antennæ fourteen-jointed with oblong joints, the last five being elongated and cylindrical. Wings with microscopic punctuations, with very minute hairs at the apex of the wing. The surface of the wing tinged with dark colour with several light yellowish spots which are without punctuations. Abdomen dark grey with faint spots.

Oviposition under natural conditions has not yet been observed, but the females can be induced to oviposit in confinement very easily. The gorged females, which can be met with not far from the host, if kept in a dry tube with a piece of dry blotting paper from 50 to 60

hours and then supplied with a small piece of moist blotting paper will be found (at least in about 50 per cent. of cases) to lay eggs readily in confinement within two to three days after the introduction of moisture. After oviposition females do not seem to have suffered very much if care is taken in supplying the requisite amount of moisture. Excess of moisture causes the fly to stick to the tube. After oviposition the female looks quite healthy and if allowed to bite will do so readily, so much so, that in certain cases they have been observed to bite twice within an hour. Eggs can be hatched quite easily in the tube they are laid in provided it is kept wet. The eggs are capable of tolerating any amount of moisture, even submergence, but they are unable to survive in the absence of moisture. Eggs of *oxystoma* and other species including *C. kiefferi** are elongate, cylindrical, and sometimes a little curved. The amount of curvature varies and at times examples of straight ones are also met with. Each egg very slightly tapers towards both the ends. The anterior end is marked with micropylar cap. When freshly laid the egg is white in colour, but it soon begins to change to dark brown. The chorion is smooth and exhibits no sign of sculpturing. The egg of *C. oxystoma* is characteristic in appearance, being surrounded by a fringe of very minute curled scale-like spines, the function of which is not yet understood but perhaps it may be of the nature of floats as in Anopheline eggs. In confinement eggs are generally laid in several batches, each batch consisting of 7 to 10 eggs which are arranged regularly in a line. The number of eggs laid by a single female varies according to the physique of the mother fly but a maximum number of 156 has been counted. A single egg measures $\frac{1}{2}$ mm. in length and one-twelfth mm. in breadth. The incubation period is governed by the temperature. Larvæ were obtained in the month of May in about three to four days from the date of deposition, while in November seven days were necessary for the eggs to hatch. The longest period recorded was eleven days between December and January 1918.

The young larva comes out of the egg through a longitudinal aperture from the micropylar end; after hatching the chorion does not collapse.

The larva when empty of food is similar in its general appearance to a snake. It is $3\frac{3}{4}$ to 4 mm. or even a little more in length when adult, ochre white, translucent, smooth, with yellowish-brown head. The head, which is chitinous from the beginning, is provided with a number of small bristles. The body consists of 12 segments which are almost devoid of bristles or hairs when the larva is young, but the adult larva develops a series of small hairs on its lateral margins which are arranged

* This species is now known as *C. pattoni*, Kieffer, (*Bull. Soc. Ent. France* 1921, p. 7)—Editor.

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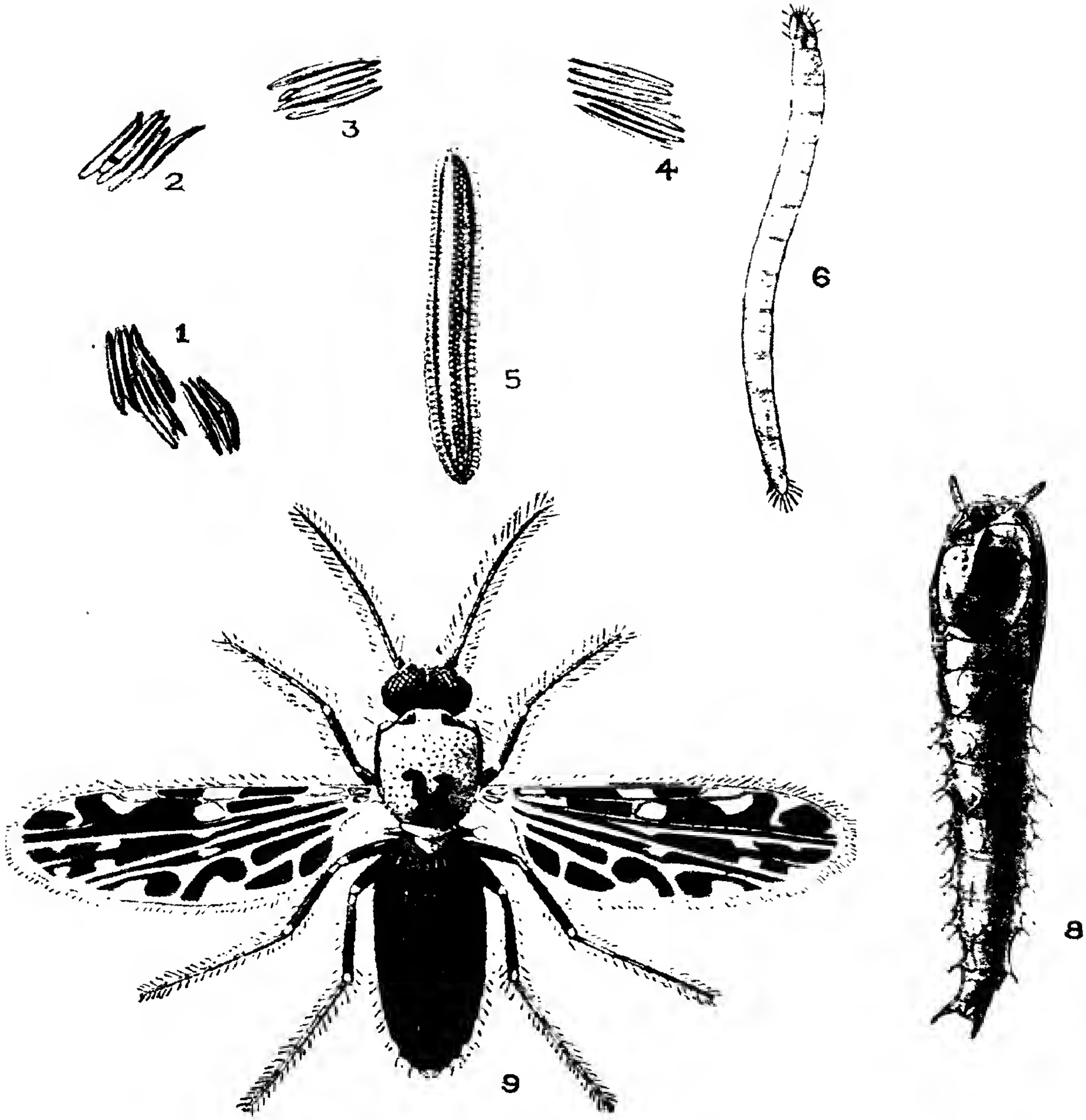

Culicoides oxystoma.

in two pairs on each of the thoracic and one pair on each of the abdominal segments. These hairs are very minute and delicate but they differ in number in different species, and hence they serve as one of the points in distinguishing one species from another. The anal segment of the adult larva is the narrowest and longest and carries four pairs of small hairs on the lateral margin at its apex and two pairs on the dorsal surface. The young larva possesses a pair of very minute eye spots but the adult larva has two pairs. There is no trace of true stigmata; the tracheal tubes originate from the apex of the caudal end to which four pairs of very thin blade-like papillæ are attached.

The number and shape of these papillæ differ in different species of the genus. In the larva of one very small species two pairs of such papillæ have been seen. The larvæ in the young stage have a slow serpentine motion but as they grow bigger they assume a rapid vibratile motion. Patton has compared them to giant spirochætes. They remain very often lying under their food material, especially when they are young, but in the advanced stage they are seen very often coming to the surface of the water and remain in recesses, exposing their heads out of water.

The adult larva of *C. oxystoma* develops two pairs of oval reddish spots on the metathorax, the pronotum also carries several very minute dot-like spots. The larva when about to pupate gets a little swollen in the thoracic region. It then anchors itself with the aid of its powerful mandibles and starts the operation of casting away the last larval skin. The larval period lasts from two to ten weeks according to weather.

In laboratory experiments very often pupation takes place at the bottom of water but within a short period the pupa becomes buoyant and floats to the surface. A pupa which fails to float up always fails to emerge out also. The pupa is $2\frac{1}{2}$ mm. long, yellowish when freshly pupated, but turning darker as the development of the imago proceeds. The respiratory trumpets are club-shaped with a crenulated margin on one face. The stalks of the respiratory trumpets of *C. oxystoma* are not supplied with any protuberances, unlike those of the pupa of *C. kiefferi* and they are comparatively shorter. Each abdominal segment is provided with a transverse row of very minute knob-like bristles which gradually get longer towards the apical segment. The pupa at its caudal end bears two prominent hooks which aid in anchoring and locomotion. Pupal period lasts from four to seven days according to climatic conditions.

Flies of this genus occur throughout India. In Assam and Bengal some species of *Culicoides* are very common more or less throughout the year. In Assam the number of these flies noticed during July and

August 1906 was so great as to greatly worry animals and man especially during the late evening hours. Their bite is not confined to any hour of the day or night but they are specially a nuisance during the evening hours. During the hot hours of the day they are generally seen attacking in shady places. They apparently feed on any mammals but seem to be specially fond of horses, bullocks, buffaloes and goats. Fowls as well as earthworms have been seen to be attacked by these flies in great numbers. Flies of many species of *Culicoides* are in the habit of drawing more blood than they can cope with. I have marked several species of *Culicoides* at Belgachia, Calcutta, alighting upon a bull which was tied in the open air during the evening hours in September, and entering straight into the hairs to suck blood. After taking their fill, which is generally accomplished within 3 to 10 minutes, they were observed to emerge from the hairs. Many of these flies had so much blood in their abdomen that each of them looked like a small droplet of blood. Several of these gluttonous flies after the meal were seen falling down in their attempt to fly. The bite of some species is very painful in certain cases and causes swelling or sometimes reddish marks with severe irritation lasting for some time. I give below my experience in Assam about the bite of these flies. On alighting upon my body the fly was marked to insert the proboscis which caused a smart burning sensation. This after a while diminished, but a further burning sensation was again felt which might be due to deeper thrust or to the injection of salivary fluid. The irritation for the second time again decreased only to be followed by another smart sensation and at this point the fly stopped feeding.

These flies do not break open the skin sufficiently to cause blood to ooze out from the puncture. *C. oxystoma* after its feed has usually been noticed to rest near the host on a wall or any other convenient object. They have been found in most of the cases to sit at the height of about four to six feet from the floor and have a marked preference for brownish or dirty brown colour over white. This species can readily be distinguished from its sister species by the fact that it habitually sits on the wall of the stable, especially after its meal, keeping the head and the proboscis well pressed upon the surface of the wall and directed towards the earth. This peculiar attitude is so well maintained by the fly that it is often mistaken for a particle of dirt. The species in question has been found to breed in a drain of sluggish water connected with the stable drain. They breed thoughout the year but profusely during the hot and wet season of thc year. Lately this species has been seen breeding in the algæ growing in the overflow water near the well of a stable.

At Pusa there are about half-a-dozen *Culicoides* species of which one has been found to breed in the river Gandak. The flies of this species are occasionally seen to inflict their bite upon man and animals. One species has been found breeding in the hollows of trees along with *Stegomyia albopicta,* while *C. pattoni* and one other small species have been found to breed in the algæ growing in water collected near the cattle shed or water impregnated with the saliva of cattle. They are absent in the algæ grown in water situated near human habitations.

In the compound of the Dak Bungalow there is a well and a small stable close to it. *C. oxystoma*, *C. pattoni* and other species have always been seen inside the stable so long as horses are kept there throughout the year, but none of these species was found to breed in the water near the well used by human beings and where no animal was ever watered. In my opinion the selection of hosts by these and several other blood-sucking insects is closely associated with the nature of materials in which they breed. It is a well known fact that certain mosquitos as well as both biting and non-biting muscids which breed in the dung of cattle are as a rule confined in their attack to cattle only. In the same way Sand Midges breeding in close association with cattle will presumably confine their attack to cattle only. At present we are in the dark as to the factors that determine the limits of selection of hosts in these flies but further work in connection with the relation between the larval and adult food will prove of immense value in solving the problem of control of these flies.

The life-history of *C. oxystoma* may be briefly summarized as follows :—

Egg stage from three to eleven days.
Larval stage from two to ten weeks.
Pupal stage from three to seven days.

The length of life of the imago is uncertain, probably at least a month. They have been kept alive in confinement for about two weeks during which period the fly laid two batches of eggs and took five meals of blood. The newly emerged fly was found to survive in the absence of any food for 50 to 60 hours in hot weather and for a period of three to four days in the cold season. The period for digestion has been found to be the same; the gorged females, if kept in a dry tube, with a piece of dry blotting paper, digesting their food content within two days in the hot season. On the third day if not supplied with a little moisture they invariably die. Oviposition also takes place after the lapse of another two days from the time of supply of moisture. The newly hatched fly will bite readily, but preferably on the second day of its birth. The fertilized female will bite every third day but unfertilized flies and flies after oviposition will bite once or twice in a day.

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Flies of the genus *Culicoides* are found more or less in all parts of India. In Assam they are a regular pest both to human beings and animals, so much so that cultivators while working in the field have to tie a burning cowdung stick behind their backs to keep off the flies. Although the bite of these flies has a most irritant effect the nature of the harm they may do is not yet known but it is quite possible that these flies may be a medium for the propagation of some disease or other, like most other blood-sucking Diptera. No investigations however seem to have been made which would tend to incriminate these flies. The power which these flies enjoy of sucking blood from various sorts of hosts, and the fact that they suck blood more than four times during their life, and the overwhelming number in which they are found in some parts under certain climatic conditions are sufficient reasons to render their study of importance.

This paper was submitted to the Indian Science Congress, Bombay, by the late Mr. F. M. Howlett, on my behalf, but as it has not yet seen the light in its complete form, I beg to present it to the Meeting.

37.—PROTECTIVE MOVEMENTS AND RANGE OF VISION IN PLATYPEZID FLIES.

(Plate XLVIII).

By (*the late*) F. M. HOWLETT, B.A., F.E.S., *Imperial Pathological Entomologist.*

In his great work on "British Flies," Verrall has the following note on *Platypezidæ* (Vol. Syrphidæ, p. 677, 1901). "Colonel Yerbury has informed me that the males of the genus *Platypeza* hover in *dull* weather, but sit (or to some extent run) about on leaves during sunshine, and that as a rule they prefer large leaves."

Williston (N. American Diptera, 3rd edition, 1908, p. 242) remarks "The flies of this small family have been seen dancing in the air in small swarms, or running about on the leaves of underbush." In 1909 I wrote that *Platypezidæ* "may sometimes be seen running on broad leaves under trees, travelling round and round in little circles, and expending a vast amount of energy without any obvious purpose or perceptible result."

This habit of running on broad leaves is indeed extremely characteristic of the family, or at least of such species as I have encountered in this country. The peculiarity of the movement is the extreme rapidity with which it is usually executed, and which seems unnecessary in a mere reconnaissance or search for food. Moreover it is generally confined to a comparatively small area, and seems unconnected with courtship.

The description given above, of their running "in little circles," is in the case of the species here mentioned not quite correct, as its course is more often a long ellipse or a nearly straight to-and-fro path, while sometimes it consists of a series of darts in varying directions across a central space of more or less fixed extent. The area covered by these rapidly alternating movements may be about three or four inches square, or may be only about one square inch, according to the degree to which the insect is disturbed. It seems to take to flight only as a last resource.

In the field this curious habit is so constantly displayed as to afford on most occasions an easy means of "spotting" a Platypezid at sight,

whereas if it remained at rest it could not be distinguished at a little distance from many small Muscoids. The habit seemed to me so definite, although so apparently purposeless, that it was hardly to be explained as a mere exhibition of uncontrollable restlessness.

A fly of this genus (almost certainly *Platypeza argyrogyna*, de Meij.) was seen sitting on the broad leaves of a creeper in my compound on the 12th of August 1913. It happened to catch my attention while I was four or five yards away, and it was then quite motionless. I approached to within a few feet, when it suddenly began its darting and circling motions. On my retiring again to a distance of five yards, the movements ceased, but at once began again when I approached to within a few feet. This advance and retirement was repeated several times, and always with exactly the same result. The movements began whenever I got within a certain distance, this distance being smaller the more cautious and gradual the advance.

It seemed evident that the movements were executed in response to the sight of objects moving in the neighbourhood, and moreover that they followed the stimulus with remarkable regularity. The idea occurred to me that by making a series of trials at varying distances we might obtain some idea of the range and acuteness of vision in this particular fly. I procured a piece of white paper four inches square, and a roughly circular palm-leaf fan 12 inches in diameter and coloured red and blue with large gilt spots ; for the longer distance I employed my own body (in white clothes) as the moving object, against a back ground of grass and trees. These objects were shifted for varying distances across the line of sight of the fly, the minimum shift required to make the fly move being noted for each distance. Not less than five trials were made at each distance, and in the case of Fly A it is not unlikely that fatigue or a growing indifference may have decreased its sensitiveness in the latter trials ; it will be noticed that in these it appears to require a stronger stimulation than Fly B, which was tested five days later, the short distance trials being in this case omitted. Another possible cause of the greater alertness of fly B is that it was tested at 9-15 A.M., whereas fly A's tests began at 11 A.M. and continued for more than an hour in the heat of the day, a time when many insects and animals are more or less inactive.

Apart from this individual difference the results as shown on the curve (Plate XLVIII) seem on the whole very regular, and in carrying out the tests this impression of regularity was particularly strong. There seemed for each distance and each object to be a definite minimum amount of movement which had to be exceeded in order to make the fly dodge.

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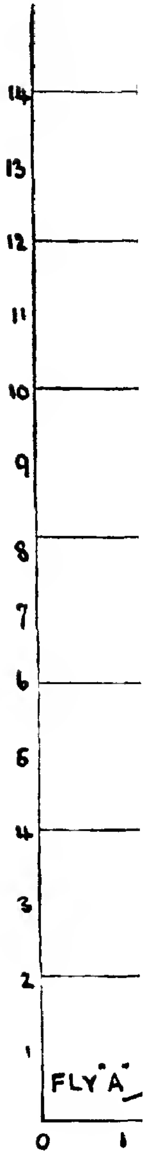


The accompanying diagram gives the various distances plotted.

An experiment conducted in this rough-and-ready way cannot be expected to give very accurate numerical data regarding the power of vision in the flies, but in view of the degree of concordance of the results and the care with which they were obtained we may take it that the general form of the curve is in all probability fairly correct.

The record of the experiment is as follows :—

Distance from fly.	Object.	Minimum shift required.	REMARKS.
Fly A—			
1′ . .	Paper 4″ sq. . . Fan 12″ diam. . Fawn hat 15″ diam.	4—6″. 4″ 6—10″	
2½′ . .	Paper . . .	6″ (once). Generally 8—10″	
	Fan . . .	10—12″ . .	Turning the fan from edgeways to broadside on was always effective.
3½′ . .	Fan . . .	12″ once; generally 15—18″.	Turning was once effective.
4′ .	Body . . .	less than 2½′ . .	I moved by stepping sideways as abruptly as possible; in the longer distances by springing quickly from one point to another.
5′ . .	,, . .	2½′	
7′ . .	,, . . .	4′	
7½′ . .	,, . . .	5½′	
Fly B—			
6′ . .	,, . . .	1′ . . .	The hand moved quickly through 1′ produced no effect.
9′ . .	,, . . .	3′ . . .	
11′ . .	,, . . .	8′ . . .	Waving the arms was ineffective; bandishing a short-handled net ineffective.
17′ . .	,, . . .	More than 13′ .	Rapidly leaping and running across the 13′ was ineffective. Trees prevented a longer run.

The accompanying diagram gives the various distances plotted.

An experiment conducted in this rough-and-ready way cannot be expected to give very accurate numerical data regarding the power of vision in the flies, but in view of the degree of concordance of the results and the care with which they were obtained we may take it that the general form of the curve is in all probability fairly correct.

A noticeable point is the individual difference between the two flies; it is possible that they were of different sexes, but the sex was unfortunately not noted in either case. The general range of vision of Fly A seems to be not more than about $\frac{2}{3}$rds of that of Fly B.

The fact that the brownish-fawn ("puttoo") hat had to be moved 6-10 inches, while a piece of white paper $\frac{1}{10}$th its area had to be moved only 4-6 inches indicates that contrast as well as size is probably a factor. The hat was not conspicuous against the background of trees, tree-trunks and grass; the white paper and the fan showed up in fairly strong relief, the paper being the brighter. The comparison of the three was carefully repeated several times, and on each occasion the hat was the least disturbing, although larger than either of the others. It is conceivable that a considerable amount of information as to the colour-sense of the insects might be obtained by more elaborate experiments with pure colours and controlled contrasts.

In the case of our own perception of motion the main consideration seems to be the plane angle subtended at two points representing the eye by the initial and final positions of the moving body, the size of the body itself having comparatively little influence. In other words, an elephant moving its body a foot forward would produce no greater impression of movement (*i.e.*, would not arrest our attention to a greater degree) than a dog moving the same distance at the same pace. The amount of lateral shift of an easily-seen object which would be necessary to attract our attention to any given degree would then be directly proportional to its distance from the eye, and within limits would be practically independent of the size of the moving object. My knowledge of human psychology and physiology is insufficient to enable me to say that this is a correct statement of the facts in the case of the human being, but if it be so, then we have in the case of the fly a very different state of affairs, as will be evident from an inspection of the curves in the diagram.

As my body was used as the moving object in all the trials with Fly B, the numbers shown in curve B are more directly comparable than those obtained with Fly A. Taking curve B, it will be seen that the degree of lateral movement necessary increases rapidly with increasing distance, and is by no means directly proportional to it as is (presumed to be) the case in human beings.

On the other hand, it appears that the results harmonize fairly well with the assumption that the amount of lateral motion of the moving body, which is necessary to induce movement in the fly, is proportional to the square of the distance. That is to say, the disturbing or attention-arresting perception of motion is proportional to the *area*

covered by the body in its movement, and not merely to the *distance* between its initial and final positions.

Now according to the mosaic theory of insect-vision originally advanced by Muller, each facet of the fly's eye commands a certain definite area of the field of view, and by the juxtaposition of these elements a composite image is built up, as we might piece together a mosaic out of little bricks. Exner has shown, however, that in many cases a certain amount of superposition of image-elements also occurs, in the sense that light from a single point may be registered by more than a single facet, and that while this will tend to decrease the accuracy with which forms are perceived it will enhance the acuteness of perception of motion, since motion of a single point will effect more than a single facet. I am unable to refer to Exner's classic work on this subject, or to treat the present example in anything but crude fashion. However, the data given may perhaps furnish a basis for a more accurate analysis.

Taking the radius of curvature of the eye as 5 mm., and the diameter of a single facet as ·04 mm., then, multiplying together the number of facets covered in a vertical direction by the height of the object, and the number covered horizontally by the lateral movement of the object, we get the following figures as to facets affected :—

6	$2 \times 12\frac{1}{2}$	—25
9	4×8	—32
14	$7 \times 5\frac{1}{2}$	—36
17	$9\frac{1}{2} \times 4\frac{1}{4}$	—40

Now if the disturbing effect of the moving object were exactly proportional to the square of the distance, there would be identical numbers of facets (*i.e.*, areas), and we could say that there was a constant minimum stimulus (the excitation of a certain number of facets) which would make a fly dodge. It is evident that they are not identical, and the discrepancy is beyond the probable limits of error.

These numbers when plotted give an indication that the minimum number of facets to be stimulated at close range in order to make the fly dodge might be expected to be about 16, and that the formula $N = (16 + 1{\cdot}5\ D)$, where D is distance in feet, will give us the approximate number of facets to be stimulated for various distances.

Assuming this formula to hold, a man 6 feet high at a distance of 30 feet would have to move rapidly over a sufficient distance to stimulate 61 facets. His height of 6 feet subtends an angle embracing $2\frac{1}{2}$ facets, so that his lateral movement must cover 24 facets ($24 \times 2\frac{1}{2} = 60$), or approximately 1 mm. ($0{\cdot}04 \times 24$) on the surface of the eye. To do this it would be necessary for him to move a distance of about 20 yards

at a considerable speed. This amount of movement of so large an object would rarely be met with under ordinary conditions but although the numerical relations here suggested obviously require verification, the paragraph has been included because it may give us a rough idea of the actual powers of vision in this particular fly. It is reasonable to suppose that the minimum movement perceptible to the fly is at least considerably less than the minimum which is sufficient to make it dodge. If we are justified in taking the latter as equivalent to the stimulation of 16 facets, let us say as motion perceived across a patch of eye 4 facets square, it seems not unlikely that the fly might be able to perceive motion which involved only two facets.

In the upper quadrant of the circle there are approximately 30 facets. Each facet thus covers about 3° of arc. In the lower quadrant the facets are smaller and more numerous, and each one commands about 2° of arc. In the above calculations it has been assumed that we are dealing only with the upper and larger facets.

If the fly sees things as a mosaic of which each element represents the amount of the visual field covered by a single facet (3°), then this mosaic would have the same definiteness as one composed of one-centimetre blocks, when seen at a distance of eight inches. Put in another way, we could paint a picture representing what we may suppose the fly sees by fixing a glass, ruled in centimetre squares, at a distance of 8 inches from the eye. Looking through each square in turn, and having a piece of centimetre-squared paper before us, we should cover each square on the paper with a uniform patch of paint representing in tone and colour the average of all the tones and colours which we could see through that particular square of glass.

Similarly the fly's vision of objects at a distance of two centimetres from its eye would show details as small as one millimetre-square, while in objects at a distance of two millimetres it could distinguish details down to $\frac{1}{10}$th of a millimetre in size.

Our own eyes enable us to distinguish points separated by only $\frac{1}{200}$th of an inch ($\frac{1}{8}$th mm.) at a distance of eight inches. This corresponds to an angular range of about $\frac{1}{40}$th of a degree, as compared with the fly's 2-3. The meaning of this curious and very characteristic habit is now, I think, made clear. The movements are executed only when the fly is disturbed by movement of some object in its vicinity, and are in all probability a defensive manœuvre. It might at first sight appear somewhat improbable that these flies should adopt as a defensive measure a series of movements which can hardly make them less conspicuous than they would be if they remained motionless. To our eyes, indeed, they are more conspicuous when moving than when

at rest, but the objection is nevertheless only an apparent one, since the extreme rapidity of the movements must make the capture of the fly a matter of very considerable difficulty for any foe. When the insect is on the wing it looks as though it would offer a distinctly easier mark than when it is darting back and forth upon a leaf.

These curious habits are not altogether isolated. We find a type of motion among *Phoridæ* not dissimilar from that of *Platypezidæ*, though less definite. Among Tipulids, *Dicranomyia saltans*, Dol., common at Calcutta and recognisable by its snow-white tarsi, waves its body gently up and down as though it were being swayed by a current of air. A gentle up-and-down motion in walking, a sort of "rolling" gait, is very often seen in predaceous Rhynchota and Orthoptera, particularly in the slender-legged Emesidæ and in the Mantidæ. The movements are generally slow and smooth, not jerky or abrupt, and the effect of them is very un-insectlike. It is probable that the impression of inanimateness, which this sort of motion certainly gives us, is also of value to the insect in enabling it to approach its prey. In the case of Emesidæ the likeness of some species of these predaceous Rhynchota to small Tipulidæ is very distinct, particularly in the field, and it is interesting to find tendencies to a similar type of motion in both groups. The case might possibly be regarded as one of convergence, but certainly not of mimicry, unless we are prepared to assume that the insects preyed upon by Emesidæ mistake them for the Tipulidæ which they know to be harmless. Emesids are considerably less abundant than Tipulids.

The device of securing a degree of invisibility by means of rapid motion is familiar in those spiders which when alarmed cause their webs and bodies to quiver so rapidly that we only perceive the insect as a sort of blurred spot in the middle of the web. I cannot recall any other example of this vibratory type of movement being described as a defensive measure, and it may therefore be of interest to mention the case of two Tipulidæ which I noticed in July of this year (1913). These show two varieties of movement which are in my opinion to be interpreted as defensive. As in the case of the Platypezid, these movements were exhibited apparently in response to the movement of comparatively large objects in the insect's vicinity, but no definite measurements were made. I simply noted that when I remained motionless at some little distance, the insects sat still, whereas when I got near them or after approaching with caution, waved my hand a foot or two away from them, they began their movements, generally quieting down again within two or three minutes after I had again retired to a little distance. The movements differed curiously in the two species. In the first one observed (both were sitting on a tree-trunk), it consisted

of a rapid up-and-down motion of the body, a sort of tetanic vibration. This was so rapid that the insect when viewed sideways was difficult to see at all, the tarsi being the only parts which could be definitely located. On the other hand when it was viewed directly from above the degree of concealment was small, merely a slight blurring of the outline of the body and femoral portions of the legs. It is probable that the fly is thus well concealed from enemies approaching on its own level; those walking on the tree-trunk on which it sits, for example. An enemy such as a bird approaching from directly above the insect will probably not be misled to any great extent, however, and in this respect the device is incomplete.

About a week later it was my good fortune to see the second Tipulid, and in this the defect just mentioned was remedied in a very simple and effective way. The body was not moved vertically up and down, but with a circular motion in a plane at right angles to its long axis so that a line from head to tail traced out a cylinder in the air. This rotary movement obscures the outline and position of the body when seen at any angle. The direction of rotation seemed not always to be the same, but of this I was not certain as the motion is confusing. As in the former case the fly started its rotation when disturbed. When more disturbed, both of them resorted to flight. It seems to me that these movements and those of web-shaking spiders are in the same category, both consisting of a vibration of the body in the middle of an elastic frame-work supplied in the one case by the web and in the other by the long thin legs. For a short-legged fly such as the Platypezid the amplitude of the body-vibrations obtainable by this method would be so small as to be quite useless for effective obliteration or the confusion of enemies, and the rapidly-alternating translatory motion of the whole insect (quite distinct from "running away" in the ordinary sense) may be regarded as another means of attaining a similar end.

You see the same swaying movements in *Gongylus* and other predaceous animals.

I do not know what the food of Platypezid imagines may be, but I do not think they are predaceous.

In the case of Phalangid spiders and Tipulidæ the vibratory movement renders the animal more difficult to see. Do you think that this is so in this case?

Mr. Howlett thought the motion was protective, rendering their capture more difficult than when at rest or on the wing.

38.—*GRACILLARIA SOYELLA*, VAN DEV., AND ITS PARASITE *ASYMPIESIELLA INDIA*, GIRAULT.

(Plate XLIX)

By G. R. DUTT, B.A., *Personal Assistant to the Imperial Entomologist.*

Gracillaria soyella, van Dev., occurs every year at Pusa and is usually found in Tur (*Cajanus indicus*) fields from November to March-April. The caterpillar rolls up the apical extremity of Tur leaves in the way shown on the plate and lives within the fold, eating the epidermis from inside. In the worst cases of damage the folded portion of the leaf is skeletonized and consequently dries up. The injury therefore is to a portion of the leaf only. Caterpillars of the family Gracillariadæ are generally leaf-miners, but the caterpillars of this species behave as leaf-folders. A nearly full grown larva measures 5 mm. long by 1 mm. broad; more or less cylindrical, very slightly narrowed towards the tail end. The segments into which the whole body is divided are quite distinct, and are 13 in number including the head. The whole body bears sparse erect hairs of dirty white colour, the general colour of the whole body being creamy yellow, but some of the caterpillars appear green when seen from above, on account of the green food present in the alimentary canal being visible through the transparent integument. The head is bilobed, of a slightly deeper tint than the rest of the body. There are about six raised black circular marks or dots, a little behind the base of the mandibles on each side; they are distributed into two lots, *i.e.*, four in one lot touching each other, and two in the other. The head including mandibles is longer than broad. The body is furnished with 3 pairs of suckerfeet excluding the anal pair of claspers. The spiracles are too minute to be seen under an ordinary low power hand lens. The extreme tail-end has a brownish spot on it.

Pupation takes place inside the leaf-fold. The pupa measures a little over 5 mm. long and 1 mm. broad across the thoracic region. It is cylindrical and tapers towards the tail-end. There are nine dorsal and five ventral segments exposed to view. Each segment bears two transverse rows of spiny hairs; those of the anterior row are stouter than those of the posterior one. The tail-end is furnished with four processes which remain entangled in the silk fibres spun by the full

grown larva, and thus keep the pupa inside the leaf-fold. The pupal stage lasts for about 8 to 9 days.

Pupated	24·i·14	26·i·14	14·ii·15
Emerged	1·ii·14	3·ii·14	21·ii·15

The spread of *Gracillaria soyella*, van Dev., in Tur fields, is controlled by a small Chalcidid parasite, *Asympiesiella india*, Girault, which is a tiny insect, measuring only 2 to 4 mm. in length and with a beautifully metallic green body. The male of this species is quite distinct from the female and can be easily distinguished by its flabellate antennæ and short abdomen (Figs. 5 and 6). The abdomen of the female is very long and slender, tapering almost to a point, and the antennæ simple (Fig. 4).

The caterpillar of *Gracillaria soyella* secures itself completely inside the fold of a Tur leaf. The folded part is very well "glued" from all sides by means of the salivary threads (fig. 1) but the sharp, long, and thin abdomen of the female parasite finds an easy entrance into the fold. The caterpillar is felt by moving the tip of the abdomen inside the fold, and when got at is stung to death; all the parasitized caterpillars have invariably been found lifeless.

The egg has never been found on the body of the caterpillar, but on four different occasions it was discovered in the delicate silk webbing spun by the caterpillar while cementing together the folds of a leaf (Fig. 1). And out of these four occasions only once I succeeded in rearing the egg to the adult stage.

The larva is a voracious feeder, and is always found on the back of the host caterpillar feeding from outside (Fig. 2). Within two days after hatching it consumes the whole of the caterpillar, leaving nothing but the integument, and attains its full size. On the fourth day the excreta are discharged and the larva becomes quiescent. A little diminution in size occurs, and on the following day the larval skin is cast off, exposing the pupa (fig. 3). The pupa lies naked in the fold (*i.e.*, the larva does not spin any cocoon); the tail-end remains attached to the leaf.

On the seventh day after pupation the adult parasite emerges, cutting a hole in the leaf fold. From the egg to imago, it takes about 13 days or two weeks, in January and February.

A freshly-hatched larva is almost colourless and measures 0·68 mm. long and 0·16 mm. broad. The head is the broadest part of the body; the segments are quite distinct and the body laterally faintly indented. Two days' old larvæ were measured and were found to

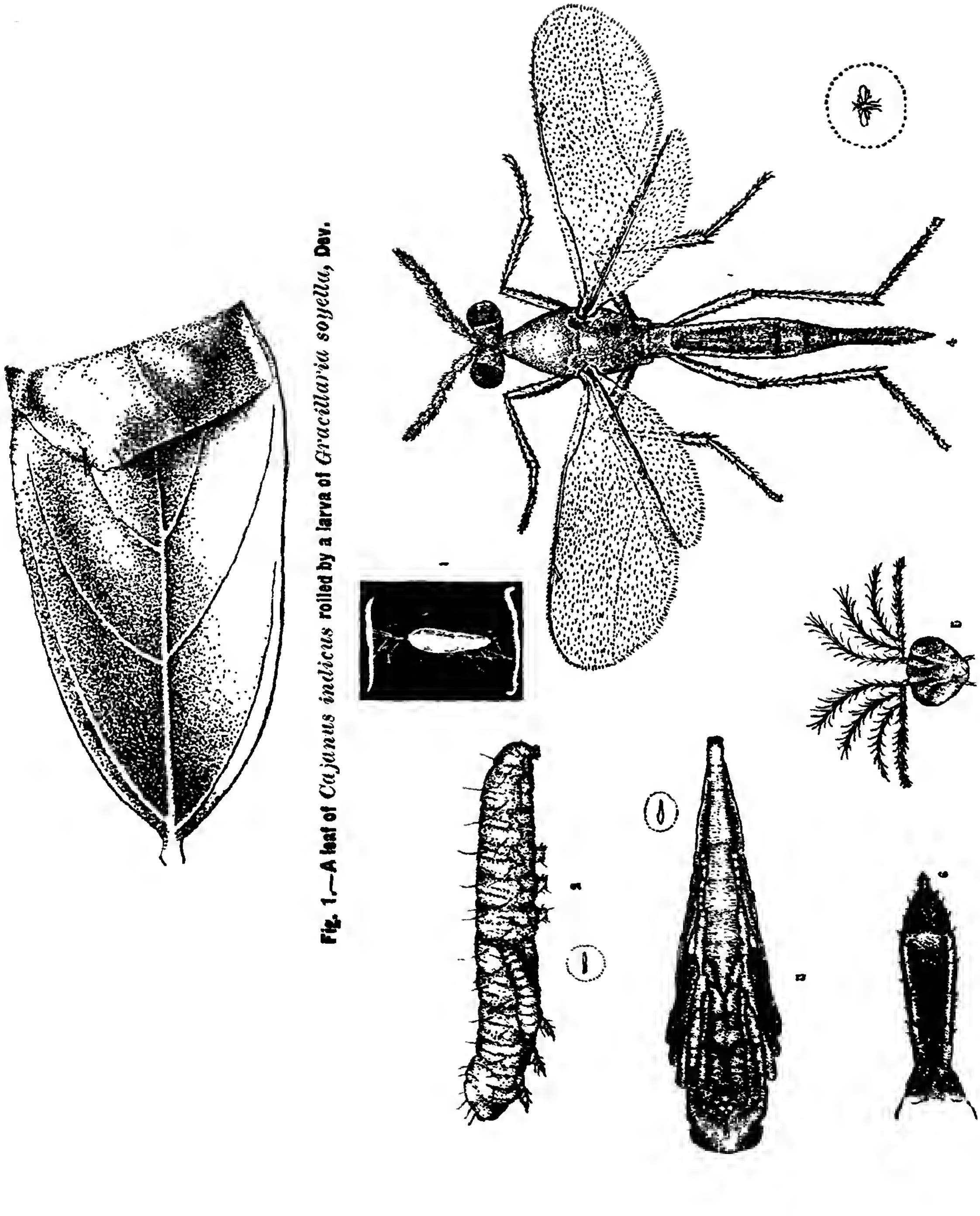


Fig. 1.—A leaf of *Cajanus indicus* rolled by a larva of *Gracillaria soyella*, Dev.

vary in size considerably. The dimensions in millimetres are given below :—

Length . . .	2·76	2·105	1·841	1·40	1·315
Breadth . . .	·66	·605	·605	·45	·526

The bigger larvæ in two cases were reared to female adults and one smaller larva to a male adult. Of the rest no record was kept. There is generally some difference in size of males and females of the same species and consequently in their respective larvæ also ; but amongst the Hymenoptera sometimes the individuals of the same sex are also noticed to vary in size. This has been ascertained to depend on the amount of the nourishment received during the larval stage. In the case of this species one female pupa was found to measure 1·84 mm. long and 0·21 mm. broad, while the normal size of a female pupa is 4 mm. by 1 mm.

A full grown larva which had passed out excreta and entered on the quiescent stage before pupating looked almost pale white, a very slight yellowish tinge appearing on the central segment only. A pair of tubercular processes on the forehead, each ending in a point, probably represent the antennæ. The body tapers both ways, but the head end is broader than the tail end. The segments of the body become quite indistinct.

A female pupa is 4 mm. long by 1 mm. broad. The head and thorax together are only about two-thirds as long as the abdomen. The abdominal segments are not very distinctly marked, and the whole of the abdomen tapers regularly towards the tail end almost to a point. The antennæ, mouthparts, and legs are all folded symmetrically on the ventral side. The head is not so broad as the thorax which is the widest portion : the thoracic segments are distinct dorsally.

The male pupa is much smaller than the female pupa ; its length is 2·5 mm. only. The abdomen is longer than the head and thorax together but not so long as in the case of the female pupa ; the rest similar.

Nearly six hours after pupation the head, thorax, and the wing pads of the pupa become fuscous, and the colour deepens from day to day. On the fourth day the sutures bounding the mesonotum and the scutellum become quite distinct. The whole of the mesonotum turns black leaving only a longitudinal whitish line along the middle. On the fifth day the whole pupa is black and on the sixth day a greenish metallic tinge is also observable pervading the entire pupa. On the seventh day the thin pellicle covering the pupa is cast off and the adult parasite emerges. The empty pupal skin, which is left behind in the leaf fold, is of a dirty black colour.

One year on five different occasions and in different fields actual countings were made to ascertain the extent of parasitization. The following Table shows the results obtained :—

—	No. of folds examined.	No. of folds found.		No. of caterpillars found.		Adults.	Pupæ.	Pupal skins.	Larvæ.	Total.
		Empty.	Inhabited.	Healthy.	Unhealthy.					
30th January 1914.	71	34	37	10	..	2	11	..	14	27
3rd February 1914.	88	46	42	7	1	..	27	..	7	34
9th February 1914.	26	15	11	1	..	..	3	3	4	10
13th February 1914.	73	34	39	8	..	..	19	5	7	31
19th February 1914.	103	28	75	48	..	..	15	3	9	27

Now a word about the systematic position of this Chalcidid. *Asympiesiella india*, was described by Girault in the *Canadian Entomologist*, Vol. XLVIII (1916) p, 341, from material sent from Pusa in 1912 and again in 1916 to Dr. L. O. Howard. The genus *Asympiesiella* was created by Girault in 1913 for the reception of *Sympiesis nelsonensis*, (vide *Trans. R. Soc. South Australia*, Vol. 37 (1913) p. 78). According to Schmiedeknecht, the genus *Sympiesis*, Först, belongs to the Subtribe *Eulophina*, Tribe *Eulophini*, Sub-family *Eulophinæ* of the Family Chalcididæ.

Regarding *Asympiesiella india*, Girault says that this Indian species differs from the North American *Sympiesis dolichogaster*, Ashmead, most notably in having the medium carina of the propodeum but half complete, and the scape less coloured. The species are congeneric. The validity of *Asympiesiella* must be left for later treatment.

39.—LIFE-HISTORY NOTES ON *STAUROPUS ALTERNUS*, WLK.

By P. Susainathan, F.E.S., *Assistant in Entomology, Coimbatore*, and C. V. Sundaram, *Sub-Assistant in Entomology, Coimbatore.*

On the 27th of November 1920 a few eggs of this moth were brought in casually with *Cajanus* leaves intended to feed nymphs of *Clavigralla*. In appearance it was round and measured 1·5 mm. in diameter ; slightly flattened on top and adpressed at bottom ; attached to edge of underside of *Cajanus* leaf. Finely sculptured with a central transparent depression.

First Instar. 29th November 1920. The newly-hatched larva is about 4·5 mm. long and 0·75-1 mm. broad, with a shiny blackish-brown head and anal segment. The first pair of legs short, the second and third long, the second longer than the third terminating in minute hooks at the tarsal extremity. The general colour of larva brown. The anal claspers are reduced to tentacle-like appendages which are carried erect. These with the flattened terminal segment give one the idea of a diminutive cobra putting out its tongue.

Second Instar. 1st December 1920. 5-6 mm. long. Head black. Colour of larva dark brown. Warts more acute and prominent in last instar. Flattened terminal segment hirsute.

One of the caterpillars was found cut up—the abdominal portion completely disappeared—points to the possibility of cannibalistic habits. The remaining larvæ kept separated.

Third Instar. 6th December 1920. 8-9 mm. long. Head shiny black. Prothoracic shield globular, dark-brown and fringed with a row of fine setæ at the posterior margin. Abdominal segment viewed dorsally light-brown splashed at intervals with dark brown and creamy white. Terminal segment brownish black, carried erect. Larva more defiant in attitude ; carries the head bent sideways with a backward curve and at an angle to the rest of the body.

Fourth Instar. 11th December 1920. Spider-like when viewed sideways. 12 mm. long. Head, prothoracic shield, underside of thorax, all three pairs of true legs, first to fourth pair of pro-legs, anal segment ventral side black. Meta-thorax, 1-6th abdominal segments are adorned with a double row of more or less spiny warts dorsally. Third abdominal segment wholly and fourth ventrally black. Fifth and sixth wholly whitish. Seventh and eighth concolorous with anal segment from

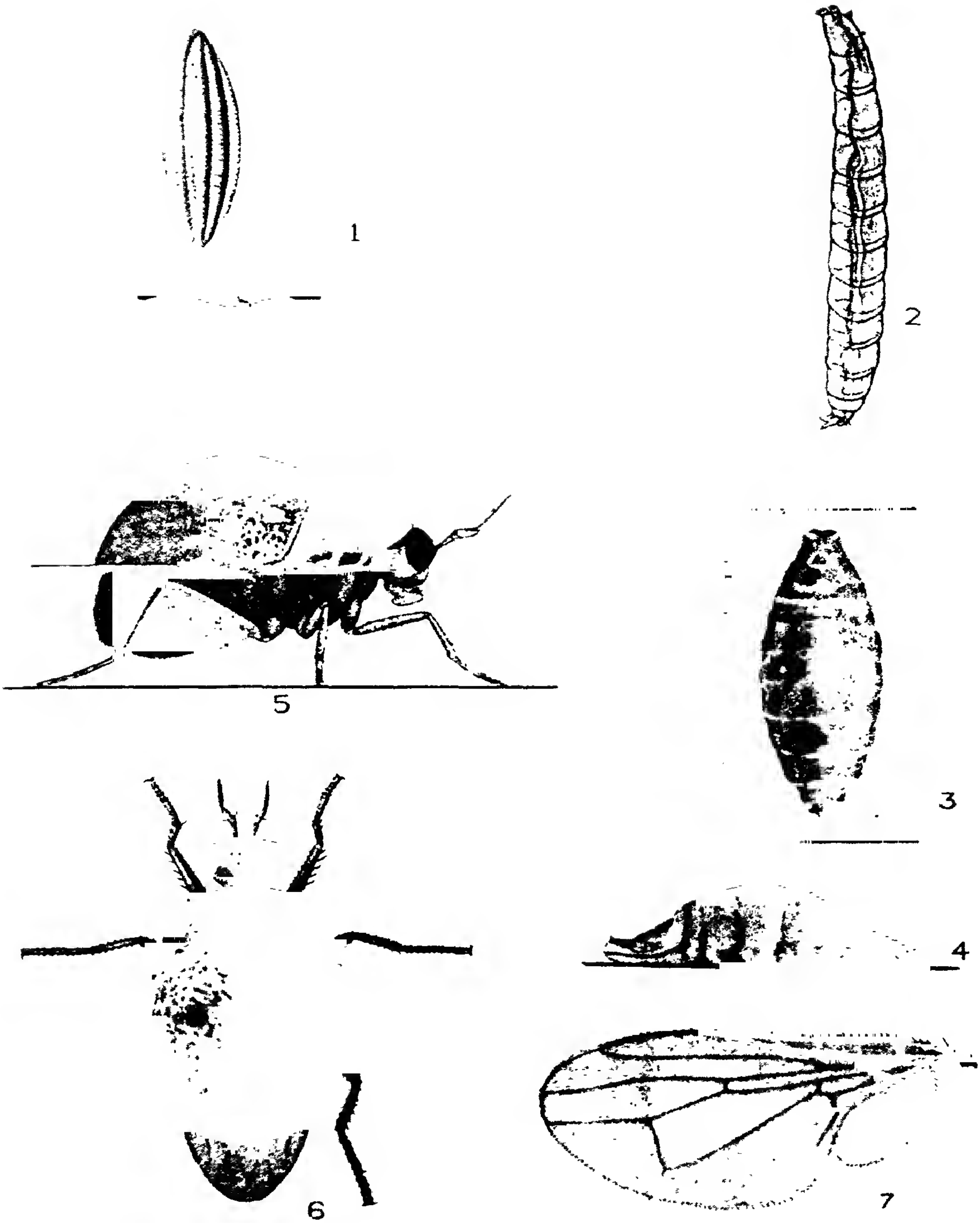
which arise two filiform and clavate processes in lieu of anal claspers. The whole body is scattered with fine short hairs arising from tiny warts more prominently on the sides ; head and ventral side of terminal segments pubescent.

Fifth Instar. 15th December 1920. 15-16 mm. long. General scheme of colour much about the same as in the last moult, except that the black of the head, prothorax, etc., is replaced by dark grey ; apical areas of femora and tarsi of legs hairy, swollen and dark-brown. The warts on the dorsum are more pronounced, asterically arranged with a central depression. First and second abdominal segment ashy-white. The third and fourth abdominal segments streaked glossy black. Minute ashy white specks are scattered all over the body. The larva is active and when disturbed assumes the spider-like appearance by bringing round the terminal segment and throwing its head backwards in the form of a loop.

Sixth Instar. 22nd December 1920. 20-21 mm. long. Body covered over by minute ashy-grey granules. Head mallet-shaped. A mid-dorsal linear streak, and a pair of zigzag striæ connecting the lateral projections, white. The penultimate abdominal segment carries spiny processes. Outer area of prolegs striated velvety black, and streaked with white. Larva more pubescent than in previous instars. Active in habits ; when disturbed throws forward the tentacle-like legs and assumes a threatening aspect, moving the body and legs to and fro in convulsive efforts.

Pupa. 2nd January 1921. Pupa 18-19 mm. long by 5-6 mm. broad. Dark brown in colour and shiny in appearance. Pupa found enclosed in a slight cocoon of yellow fibrous silk covered over by leaves.

Imago. 11th January 1921. Moth emerged.



CELYPHUS OBTECTUS.

EXPLANATION OF PLATE L.

Celyphus obtectus.

Fig. 1. Egg ($\times$ 34).
Fig. 2. Larva ($\times$ 16).
Fig. 3. Puparium, dorsal view ($\times$ 10).
Fig. 4. ,, side-view ($\times$ 10).
Fig. 5. Fly, resting position, side-view ($\times$ 10).
Fig. 6. ,, ,, ,, dorsal view ($\times$ 10).
Fig. 7. Wing of fly ($\times$ 16).

40.—NOTES ON THE LIFE-HISTORY OF TWO SPECIES OF CELYPHIDÆ.

(Plates L—LI).

By S. K. SEN, B.Sc.

(1) *Celyphus obtectus*, Dalm. (Plate L).

In nature eggs are laid on cow-pea leaves, old green, or yellow leaves—especially the latter—being generally preferred. The eggs are generally deposited scattered along the veins on the under surface of the leaves.

Imagines are hardly observed at noon, but are seen in great numbers in the earlier part of the day jumping, instead of flying, from twig to twig.

In captivity Celyphids laid eggs in a variety of situations, on leaves, in empty tubes, on cork-pieces, etc. A gravid female has a remarkably bulging abdomen and can lay as many as 60 to 70 eggs. They are laid singly.

The egg is about 1 mm. in length, white, elliptical, blunt at both ends, with four longitudinal ridges which meet at the extremities, the spaces between the ridges being finely transversely striated. A central, narrow, shallow depression runs longitudinally along the middle. Close to the extremities are two parallel rows of greenish spots, the ridges themselves being also finely and indistinctly spotted. The ridges join to form a rather thick protuberance in one extremity whereas in the other extremity the two middle ridges do not quite meet so that there is a fine slit-like depression in the tip of the end. The incubation period is from four to five days.

In nature the larvæ are found occupying the upper surface of old green and more frequently of degenerated yellow leaves and they have been frequently found covered with small bits of moist cow-pea flower or pieces of moist leaf.

Larvæ hatched out in captivity at first remain coiled round the egg-shell for from two to three hours after which they slowly uncurl themselves and move about apparently in search of food, the flies being bred out on moist, slightly rotten cow-pea leaves.

The larva is white, translucent, tapering at both ends and with 13 segments. The fifth, sixth, seventh, eighth and ninth segments are subequal, the larva being broadest at this region. The apical portion has two fan-like processes consisting of several rows of indented plates

U

which apparently assist the larva in locomotion. The jaws begin from the middle of the second segment and terminate near the apex without quite reaching it. The tracheæ run along almost the entire length of the larva from the anal region up to second segment, and, after ramifying, terminate in two pairs of spiracles. Both pairs of spiracles open dorsally, one close to the posterior apex and the other just beyond the second segment, the larva being therefore amphipneustic. The antennæ are represented by two conelike jointed prominences occupying the dorsal pre-apical portions. The fat bodies run in a somewhat zigzag fashion extending from just beyond the posterior end of the tenth segment to near the anterior end of the fourth. The anal segment is furnished with two fairly big defined prominences the use of which is not understood.

The larvæ are negatively heliotropic ; though habitually very sluggish, when exposed to the bright glare of the sun, they try to hide themselves in the folds and corners of the leaves with remarkable rapidity. To successfully breed them out a very careful regulation of moisture is necessary. The leaves offered as food should not be in an advanced state of putrefaction and moisture should be supplied preferably twice a day. The larvæ seem to live upon the scrapings of the leaves rejecting the net-like reticulation. They have a characteristically wrinkled appearance.

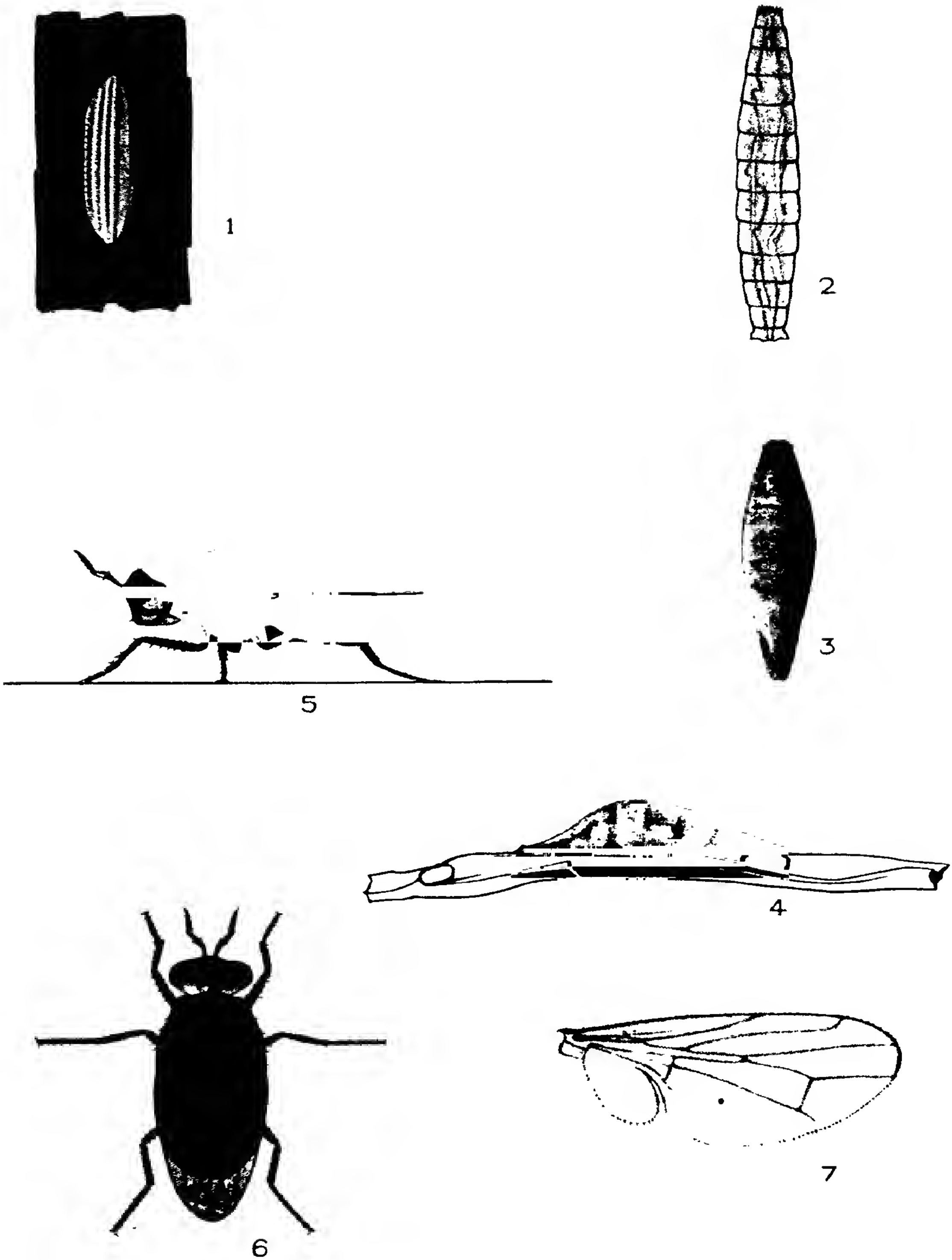
Larval period is from 7 to 10 days.

The larvæ pupate on both sides of dry leaves.

The pupa, which is about 4 mm. in length, is convex, dirty brown with a greenish tinge, with scattered white chalky patches, bluntly tapering at both ends, the posterior end being more pointed than the anterior, indistinctly divided into thirteen segments, the lines of segmental divisions being more deeply coloured than the segments themselves. These lines except the first and the last pairs are followed posteriorly by short dark lines. The antennæ point outwards as two very small dark prominences. The posterior spiracles, which are distinctly visible in the extreme end of the anal segment, are followed anteriorly by two reddish-brown spots. Two irregularly-shaped but symmetrical white lateral patches on fourth, fifth, sixth, seventh and eighth segments and two somewhat transparent circular spots symmetrically placed on two sides of the sixth segment. The pupal period is from 9 to 11 days.

The fly emerges through a slit on the dorsal surface near the apex.

The bulging scutellum of the freshly-emerged fly is at first somewhat transparent, very soft and colourless but it gradually develops colour and hardens.



CELYPHUS SCUTATUS.

EXPLANATION OF PLATE LI.

Celyphus scutatus.

Fig. 1. Egg (×34).
Fig. 2. Larva, one day old (×34).
Fig. 3. Puparium, dorsal view (×10).
Fig. 4. ,, side-view (×10).
Fig. 5. Fly resting position, side-view (×10).
Fig. 6. ,, ,, ,, dorsal view (×10 .
Fig. 7. Wing of fly (×16).

In nature *Celyphus obtectus* appears to have a number of varieties displaying various shades of colour between yellow and blue, the scutellum also showing varying grades of smoothness, some having a distinctly rough surface. Yellow or the intermediate ones have hardly been found possessing a smooth scutellum, but in the Blue ones both smooth and rough surfaces are seen. So far as has been studied, in captivity the Yellow kind has never been obtained from eggs laid by the Blue variety nor the Blue from the Yellow.*

(2) *Celyphus scutatus*, Wd. (Plate LI).

This does not appear to be an abundant species in nature. They can be captured in small numbers by sweeping grass in moist situations.

Considerable difficulty was experienced in rearing out this species. Of the several lots experimented with, only two could be made to lay eggs which were deposited along the margins of grass blades, and on one occasion on rotten *Duranta* leaves.

The egg, which is less than 1 mm. in length, is ellipsoidal tapering at both ends, slightly depressed laterally, white, with four longitudinal ridges, the spaces between the ridges being transversely and finely striated, the sides of the egg being distinctly, and the ridges indistinctly spotted, the latter converging at the extremities which are rather abruptly pointed. The incubation period is from four days to one week. Very few larvæ were discovered in their usual habitat. They were found lying inside the folds of moist, slightly rotten, yellowish-green grass-blades.

The larva is white, transparent, very bluntly tapering at both ends and with thirteen segments. The third, fourth, fifth and the sixth abdominal segments are subequal, the larva having the greatest breadth at this region. The apical portion has fine projections which, as in the previously described fly, probably assist the larva in locomotion. The tracheæ follow a rather irregular course along almost the entire length of the larva and terminate at both ends in two pairs of spiracles. The anal segment is indented in two (apparently four) distinct depressions. The anterior pair of spiracles occupies the pre-apical portions, both pairs of spiracles opening dorsally. The white bodies, shaped posteriorly into two bulb-like structures, extend from the posterior end of the tenth segment to three-fourths the length of the fifth, the bulb-like

* NOTE.—Eggs of these insects apparently derive yellow colour merely by capillary attraction of water containing colouring matter from rotting leaf. When placed in water or alcohol all become white. The Blue variety has been seen to lay white eggs as well as "yellow" ones. The yellow variety has been seen to lay "yellow" eggs as well as white ones. Apart from the colour, there seems no difference in the two.

structures occupying the portion lying between the posterior end of the tenth segment and the middle of the ninth. The antennæ are represented by two fine prominences in the pre-apical portions. The jaws occupy the portion lying between the middle of the second and that of the third segment.

The habits of the larva are very much like those of the one previously described.

The larval period varies from 7 to 10 days.

One interesting fact about the larvæ is that for pupation they would seem to prefer narrow round grass-blades to broad ones so that the width of the blade is hardly sufficient to hold the whole pupa.

While pupating the larva does not evidently shrink as much in length as the other species.

The pupa is, as in the previous species, plano-convex, bluntly tapering at both ends, narrowed to a greater extent posteriorly than anteriorly, dirty yellowish brown, with segmental lines indistinctly visible, and the details very much hidden from view owing to the deposit of a scaly matter the origin of which is not understood. In other respects the pattern of the pupa is very much like that of the other species, the pupal period being also practically the same.

The above notes, which are very scrappy and incomplete, were written by the author shortly after he commenced the study of Entomology. It is proposed to resume a detailed study of this interesting group of insects with special reference to the function of the remarkable scutellum, and correct any errors that may have possibly crept into these notes. The chief importance in this paper naturally attaches itself to the plates, there being on record, so far as known to the writer, no illustration of the early stages of any representative of this family.

Mr. Sen's paper is very interesting, as, prior to his work, none had been done on the life-histories in this family and no one knew where to look for early stages of the flies. Breeding alone can settle the specific limits of *Celyphus obtectus*, and probably several of the described species of the genus are only varieties of it.

Have you got any definite characters which would distinguish the larva of one species from that of another? In describing larvæ it is very necessary to give comparative distinctions; when a single species only is described, most probably the diagnostic distinguishing point is overlooked. Descriptions of larvæ for bionomic purposes without comparison with other nearly related species are comparatively worthless. I have had much trouble in this respect in other groups. It is better to defer description till comparative work can be done.

We felt this difficulty with Tabanid larvæ, where the life-cycles are very long and one has to wait till the emergence of the adult. In the case of the two species described in this paper, I distinguished the larva of *scutatus* from that of the other by the bulb-like structure in the fat bodies.

41.—PRELIMINARY OBSERVATIONS ON THE OVIPOSITION AND LIFE-HISTORY OF *MICROBRACON LEFROYI*, A BRACONID PARASITE OF *EARIAS INSULANA*.

By M. AFZAL HUSAIN, M.A., (CANTAB.), *Government Entomologist, Punjab, and* UMRAO BAHADUR MATHUR, L.AG., *Agricultural Assistant, The Punjab Agricultural College, Lyallpur.*

Introductory. The spotted Bollworms — *Earias insulana*, Boisd., and *E. fabia*, Stoll —— have, for many years, been the worst pests of cottons in the Punjab. They are of general occurrence throughout the Province and not a field in the whole of the cotton-growing tract is free from their attack. They make their appearance every year and are so commonly met with that the Zamindar has learnt to regard their presence as nothing unusual, and a damage up to 10 per cent. has come to be regarded as not abnormal. During some years, however, these bollworms increase so tremendously that they devastate almost the entire cotton crop and cause great economic disaster. In 1905 the loss to this Province caused by the ravages of these insects was estimated at 2 to 3 crores of rupees.

The study of the causes of the failure of the cotton crop in 1905 led to the belief that during normal years the parasites of the bollworms keep them in check so effectively that their numbers do not increase sufficiently to do great damage. Lefroy, who carried on the investigation in 1905, says :—" The peculiar feature of the present case is the absence of parasites ; this is very marked and is a most striking circumstance. Normally when the bollworms increase with plentiful food, their parasites increase more rapidly, and keep down their numbers. The parasites are in fact, the principal check on their increase, and had they been present in normal quantities the bollworms would probably have been checked."(1)

Of the parasites of the bollworms the one to which the credit of being the most effective has been given, is " a small Ichneumon fly (*Rhogas lefroyi*, Ashm.) which is the principal and the most abundant one, increasing rapidly and destroying a very large proportion of bolworms in normal years."(1) Thus according to Lefroy (1) the serious failure of the cotton crop in 1905 was the result of great and sudden reduction in the numbers of this parasite; he says :—"The most important parasite which generally checks the bollworms was, I believe, entirely absent from the majority of the cotton districts." From these considera-

tions originated the idea of helping nature in the multiplication of these useful insects and thus control the bollworms.

It was 15 years ago that the theory of checking the bollworms through the agency of *Microbracon* (*Rhogas*) was first propounded by Lefroy, and ever since, this method of dealing with the problem has been advocated year after year, as the only effective way of eradicating these dangerous pests of cottons. It, however, seems strange that, in spite of the importance attached to this Braconid, even the preliminary facts, the knowledge of which is essential for the successful use of parasitic insects, have so long been left uninvestigated. Opinions, more the expressions of individual convictions than the results of scientific investigations, have been put forth, from time to time, some in favour of the parasites and others against them ; but no one has attempted to test experimentally the efficacy of this method of control, or has tried to work out the problems connected with it. In fact, after 15 years our ignorance is so great that we do not even know the number of eggs laid by a female *Microbracon lefroyi*. In the Punjab the distribution of parasite boxes has gone on for a number of years but no definite figures are at hand to show whether this means of fighting the bollworms has been effective or not. It was, therefore, thought desirable to investigate the whole question, and to find out if our methods of dealing with the problem were worth continuing. A complete knowledge of the life-history, bionomics and behaviour of a pest, and its parasites, in nature and under domestication, is an essential preliminary to an effective campaign against a noxious insect. A number of experiments was started to test the efficacy of *Microbracon* as a check against the bollworms and a large number of these parasites was bred in the laboratory.

Dealing with the causes that brought about the reduction in the number of *Microbracon*, Lefroy remarks :—" The only abnormal circumstances that I can find is the extreme cold of the preceding winter, a cold which may have destroyed *Rhogas* while leaving the bollworms," and our observations support this view. *Microbracon* seems to be more susceptible to low temperatures than the bollworms. Thus its numbers are very much reduced in winter and it again appears very late in summer. This gives the bollworm a start. The abovementioned fact brought us face to face with the question of breeding this parasite throughout the winter so as to have a fair supply of it at the very time that bollworms appear on cotton.

Moreover, so far, the parasites when required for distribution among the Zamindars were collected from the fields and this necessitated the examination of a very large number of bolls to discover those containing parasitized caterpillars. This process is essentially wasteful and cum-

bersome. Therefore the work was started with the purpose of finding out the best methods of breeding *Microbracon* on a large scale in the laboratory, and incidentally to study the life-history of this parasite.

Rearing technique. Unfortunately we in the Punjab do not possess an insectary and the want of a proper breeding place for insects has made our work very difficult and many breeding experiments have failed at a stage when they promised to give interesting results. The delicate parasitic grubs require conditions which are difficult to attain in an ordinary working room not fitted for the purpose of breeding insects. During winter the temperature in the laboratory fell too low, retarding the proper development of the insects, and during summer, it rose too high and the host-caterpillars died before the parasitic grubs had finished their feeding and in many cases *Microbracons* also died of too much heat.

Attempts at breeding these insects were first made during the winter of 1919. With a view to provide, as far as possible, conditions natural to *Microbracon*, twigs of cotton attacked by the bollworms and in some cases potted cotton plants thus affected, were kept in large gauze cages 18 inches × 18 inches × 24 inches, and into these the female *Microbracons* were liberated. They were left for days and on examination of the caterpillars of *Earias* we found that none were parasitized, and no eggs were discovered, and very probably none were laid. During day time these parasitic insects were seen moving about on the side of the cage which was towards the windows and not attending to their business.

Observations were restarted in July 1920, and completely artificial conditions were resorted to. The females of *Microbracon* were kept in small excavated glass blocks with a cavity about an inch in diameter and ½ inch deep; they were covered with glass lids. The caterpillars of *Earias* were introduced singly into these blocks and removed when paralyzed and oviposited upon. The female was seen to paralyze the caterpillar within a short time of its introduction and to oviposit upon it. The observations on the development of the grubs could therefore be recorded easily.

In the beginning we provided dilute honey for *Microbracons* to feed upon, but later on, this was found to be unnecessary, the insect, as shall be mentioned later on, obtaining sufficient nourishment from the liquid oozing out of the punctures made by her in the body of the bollworms.

Microbracon lefroyi is in its grub stage an external parasite on the caterpillars of *Earias insulana*, and *E. fabia*. Dudgeon and Gough($_2$) have described the species found in India as *Rhogas lefroyi*. Fletcher ($_3$), however, states that while some of the specimens from Lyallpur agree with the description of Dudgeon and Gough, others differ markedly from

it. In fact, it remains to be seen to how many different species of *Microbracon* are parasitic on *E. insulana* and *E. fabia*.

Description. The following is the description of *Microbracon* (*Rhogas*) *lefroyi* given by Professor Brues.($_4$) :

"*Female.* Length 2-3 mm.; ovipositor slightly longer than the abdomen, but not quite so long as the abdomen and propodeum together. Body honey-yellow, varied with black and piceous, legs usually somewhat lighter and the sides of the abdomen often much paler. Black markings variable; in melanic specimens they include spot on front above base of atennæ, ocellar space, occiput, antennæ, stripe on each of the three lobes of mesonotum, scutellum, propodeum, irregular marks on pleuræ, abdominal segments three to five, except narrow lateral border, and sheaths of ovipositor; in light specimens the entire body is pale-honey-yellow with only the flagellum of antennæ, tips of mandibles, ocellar triangle, clouds on the second and third segments, and ovipositor black, piceous or brown. Wings faintly to distinctly tinged with brown, the stigma and veins fuscous. Antennæ 25 to 27-jointed, the joints slightly decreasing in length to apex, the basal ones barely twice as long as thick. Mesonotum shagreened, scutellum shining; propodeum distinctly shagreened, but often more nearly smooth basally toward the middle, without median carina except at extreme apex which is finely areolate; mesopleura finely shagreened, with a narrow polished strip along its posterior margin. Abdomen broadly oval or nearly circular in outline; first segment twice as wide at apex as at base, posterior corners separated by deep grooves, median field triangular, second segment four times as broad as long, with an obsolete median carina; third segment a little longer than the second; following shorter, entire abdomen except corners of first segment finely roughened, without distinct punctures or reticulations, except sometimes on the second and third segments near the middle; second suture finely crenulate. Wings are figured by Dudgeon and Gough.

"*Male.* Length 2 mm. Similar to the female with the antennæ 24 to 25-jointed and the head and thorax generally darker; the abdomen has the sixth segment black and lacks almost all the yellow at the sides although the first two segments are yellow and usually paler than in the female.

"There is an enormous amount of colour variation in the large number of specimens examined, a slight variation in the number of antennal joints and in the sculpture of the propodeum and abdomen but none of these seem to be in any way definite or correlated."

The time of occurrence. The time of occurrence of ***Microbracon efroyi*** differs in the different localities of the Punjab. In the south of

the Province, *e.g.*, Hansi, they appear very early and have been collected in July and August. At Ferozepur they are seen in September and October. At Lyallpur we get them from November to January.

Paralyzing the caterpillar of Earias. To study the process of stinging, the female *Microbracons* were introduced singly into the excavated glass blocks mentioned above, and caterpillars of *Earias* were put in, one at a time. As soon as the female discovered a bollworm in her proximity it prepared for the attack. The bollworm as compared to the Braconid is a fair-sized object, and moves about quite quickly in the hollow of the glass block, and it must be said that, taking everything into consideration, the stinging is very cleverly done. The whole process may be described as follows :—

The female *Microbracon* approaches the host quickly and cautiously, folds its wings over the back, spreads its legs to get a firm hold ; it then bends its abdomen forward between the legs and under the thorax and quickly darts its ovipositor into the body of the bollworm towards the ventral side. The parasite avoids the close proximity of the host and after stinging quickly moves off.

It is generally in the region of the abdomen that the caterpillar is stung, but sometimes it is the thoracic region and not infrequently it is the cephalic region which receives the sting.

If properly done a single injection is sufficient to stop all movements of the caterpillar ; at any rate, two or three attacks render the host incapable of motion. The caterpillar when stung shows convulsive movements but they usually last for a very short time. In some cases, however, slight convulsive movements have been observed in a paralyzed worm 24 or even 36 hours after the attack.

The female continues to sting the paralyzed host and sometimes it stings it repeatedly at the same place. The object of this process is not very clear ; it is certainly not to paralyze the host. And the following observation shows that it is probably to obtain food. After drilling a hole by the repeated action of its ovipositor into the body of the caterpillar the female has been seen to lick the liquids oozing out of these punctures. The same thing has been noticed in some Chalcidids. It seems probable that in the laboratory the food obtained by the insect by this method is quite sufficient for it.

When a caterpillar is completely paralyzed its legs lose their hold and are slightly raised up. The prolegs remain fixed in their position, obtaining a firm hold by means of their hooklets.

The juices of the body of the caterpillar remain intact but in some cases of vigorous stinging the convulsive movements are so strong that some liquid is forced out through the mouth or anus.

The punctures made by the ovipositor of the parasite turn black and are easily seen on the skin of the caterpillar. It seems possible that the young grubs when they hatch out find it easier to get to the juices of the body of the host through these wounds than through the chitin which is probably too hard for their delicate mandibles.

Oviposition. The female whether fertilized or unfertilized starts laying eggs soon after emergence.

Eggs are laid on the outside of the body of the host. Each egg is laid singly or in groups of from two to six or more. They are usually laid on the ventral side of the caterpillar in the region of the abdomen, but they have been seen on all parts of the body, abdomen, thorax and head, on the dorsal as well as the ventral side.

It was noticed that, although the female would sting a caterpillar in whatever stage of development it might be, yet it was only on the fullgrown caterpillars that eggs were laid. In some cases eggs were laid on caterpillars which had started spinning the cocoon, and in one case a caterpillar that had completed its cocoon was attacked and eggs laid on it.

Number of eggs laid by a female. So far as we have been able to ascertain no one in India has recorded the number of eggs laid by a female *Microbracon* and what we do know is only confined to the fact ($_5$) that the largest number of eggs found on a single caterpillar is 21. This number has sometimes been regarded as the total number of eggs laid by a single female. The highest number that we have obtained so far is 219 and this from an unfertilized female. (See Table 1).

Description. The egg is elongated, with rounded ends, and slightly curved in the middle. Each egg is 1 mm. in length. It is translucent when fresh, but, as development goes on, its ends become hyaline. In about 24 hours the colour changes to yellowish and the grub is seen moving about. The grub comes out of the egg after about 24 to 26 hours. (See Table 2).

The Grub. A freshly hatched grub is a little over 1 mm. in length. It is of cream white colour with the yellowish contents of its intestine seen through its transparent bodywall. The head is very large as compared to the body, and bears small peg-shaped antennæ. It crawls about on the body of its host and when it finds a suitable place it begins to suck in the juices (of the body of the caterpillar). Generally it remains fixed to the spot where it started sucking until it is full-fed. It is a very delicate creature and once dislodged it usually does not survive, and possibly is not able to make a hole for obtaining food.

The grub stage is very short in the summer. In July it is 32 to 37 hours, in October it is 67 hours, while in winter (December) it takes more than ten days. (See Table 3).

The full-grown grub is more or less spindle-shaped being thickest in the middle. The body wall is very thin and transparent and the tracheæ , fat cells and contents of the body are seen through it.

The Pupa. When full-fed the grub leaves the host and wanders about till it finds a suitable place to pupate. (Generally, the cocoons are prepared under or in close proximity to the remains of the host.) The grub prepares a white silken cocoon and pupates inside it. In some cases the grubs pupate openly, *viz.*, without spinning a cocoon. The fullgrown grub excretes a blackish mass about two hours after finishing the cocoon. It now becomes translucent white and changes into a pupa shortly after this. The colour of the pupa is white in the beginning but it soon develops a reddish tint in certain parts, and the general colour becomes yellow. It gradually gets the colour and the markings of the adult.

The duration of the pupal stage varies with the season. In the summer it is 5 to 6 days while in winter it might take as long as 27 days. (See Table 4).

The Imago. The adult parasite emerges out by cutting a small hole near one end of the cocoon.

It is difficult to find out the length of the life of an imago. In the laboratory the males lived as long as 14 to 16 days and females as long as 28 days. It appears that in captivity the females that had laid eggs died off sooner than the females that had not laid any eggs, but as the records are from two different seasons no definite statement can be made (See Table 5).

TABLE 5.

Females that laid eggs.			Females that did not lay eggs.		
Date of emergence.	Date of death.	Total No. of days.	Date of emergence.	Date of death.	Total No. of days.
5th August . .	13th August	8	28th January	18th February	21
5th August . .	10th August	6	28th January	18th February	21
2nd October . .	9th October	7	29th January	25th February	28
2nd October . .	4th October	2	..	..	..
2nd October . . .	16th October	14	..	..	..

Copulation. The male as soon as it is introduced into the block containing the female rushes towards her and copulates. The copulation seems to be a very quick affair. The male comes near the female and bends the tip of his abdomen towards her ovipositor and within a few seconds retires. We cannot with certainty say that copulation was effected properly in the laboratory because the progeny of the females that had hatched out in the laboratory and were supplied with males, turned out to be all males. (See below).

Parthenogenesis and sex. The phenomenon of parthenogenesis has been recorded in the Braconidæ, and occurs in *Microbracon lefroyi* also. Some of the females that had emerged in the laboratory were kept without males and made to oviposit on the caterpillars of *Earias.* They did so quite readily and one female laid as many as 219 eggs without having been fertilized. All the individuals from this lot that attained maturity were males. Thus our observations agree with those of Pennington ($_6$) on *Rhogas terminalis,* Cress. The same has been found in a number of other Braconidæ. Thus in *M. lefroyi* virgin females only give males, while fertilized females give rise to both sexes.

General. Before discussing the possibilities of controlling the boll-worm of cotton by means of *Microbracon* it will not be out of place to give a very brief account of the former. The caterpillars of *E. insulana* and *E. fabia* are found throughout the year. They feed on cotton from June to January, and by then they find hollyhock and breed on it till about April, when *bhindi* is ready to provide them with food, and on this they live till cottons are big enough to receive them. The life cycle is on an average 30 days in summer but in winter it is much prolonged and may occupy as long as 116 days.

The number of eggs laid remains to be discovered. The highest number we have obtained in the laboratory from a single female has been 108. Dudgeon($_7$) obtained as many as 233. Lefroy($_8$) got 50 to 70 in captivity. The dissection of a female showed over 300 eggs complete with their shells and many more immature eggs in its ovaries. Very probably the number of eggs laid by *Earias* is over 500.

During summer the eggs hatched out in about 4 to 5 days and the caterpillar stage lasts for about two weeks. When full-fed the caterpillar spins a tough cocoon which varies in colour and may be from white to dark grey. The pupal stage lasts for about a week.

The caterpillar attacks different parts of the cotton plant according to the stage of the growth of the plant. When the plant is young they eat young leaves and bore into the buds, thus killing the growing points. When the floral buds appear they turn their attention to them and bore into them and eat unopened flowers. Sometimes shoots are bored

When the bolls appear, they attack them. They sometimes feed exposed but generally they lead the life of a borer, boring into shoots, vegetative buds, floral buds, and bolls.

Although it is premature at the present stage of our knowledge to express any view as to the efficacy of *Microbracon* as a check against *Earias* yet it will not be out of place to discuss the question in the light of what is already known.

Fletcher($_3$) is doubtful whether *Microbracon* can be an effective check against the bollworms, because the percentage of parasites in the specially looked after *parasitic plot* at Pusa is too low—12 per cent. There are, however, certain facts that are significant. So far as is known, *Microbracon* is singularly free from enemies, parasites and predators, and it lays a sufficiently large number of eggs. It therefore has great possibilities of rapid multiplication.

The life-cycle of *Microbracon* takes only ten days in summer as compared to 30 days of *Earias* and assuming that a female *Microbracon* lays only 100 eggs, only 50 of which develop into females, and assuming on the other hand that the bollworm lays 500 eggs, 50 per cent. developing into females, and assuming that in both cases other factors are the same, the progeny of one pair of *Microbracon* will be able to kill off the progeny of 500 pairs of *Earias* in the 30 days' time taken by one generation of the bollworm. Theoretically, therefore, the probability of checking *Earias* by the use of their parasite seem to be within the range of practicability.

Before we are able to give an effective help to *Microbracon* in its fight against bollworm we must be able to domesticate it, and liberate it in the beginning of the season in very large numbers.

TABLE No. 1.

Daily rate of oviposition of *Microbracon lefroyi*. 1920.

Date of oviposition.	Number of eggs deposited by the female.									
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
July—										
6th	4	..	..	..	..	..	..	..	..	..
6th to 9th	16	..	..	..	..	..	..	..	..	..
9th to 10th	4	..	..	..	..	..	..	..	..	..
10th	3	..	..	..	..	..	..	..	..	..
10th to 12th	16	..	..	..	..	..	..	..	..	..
12th to 13th	10	E	..	..	..	..	..	..	..	..

Date of oviposition.	Number of eggs deposited by the female.									
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
July—*contd.* 13th	16	..	..	..	..	..	..	..	..	..
13th to 14th	4	..	..	..	..	..	..	..	..	..
14th	8	..	..	..	..	..	..	..	..	..
15th	..	..	..	..	..	..	..	..	..	..
16th	D	12 A	..	..	..	..	..	..	..	..
17th	..	..	E	..	..	..	..	..	..	..
19th	..	..	16	..	..	..	..	..	..	..
21st	..	..	4F	..	..	..	..	..	..	..
August— 5th	..	..	..	E	E	..	..	..	..	..
6th	..	..	..	..	..	E	..	..	..	..
7th	..	..	..	1	1	..	..	..	..	..
8th	..	..	..	..	4	4	..	..	..	..
10th	..	..	..	..	D	9	..	..	..	..
11th	..	..	..	3	..	..	..	..	..	..
12th	..	..	..	11	..	F	..	..	..	..
13th	..	..	..	D	..	..	..	..	..	..
October— 2nd	..	..	..	..	..	..	E	E	E	E
3rd	..	..	..	..	..	..	4	7	..	4
4th	..	..	..	..	..	..	14	8D	6	20
5th	..	..	..	..	..	..	17	..	17	23F
6th	..	..	..	..	..	..	7	..	17	..
7th	..	..	..	..	..	..	9	..	20	..
8th	..	..	..	..	..	..	7	..	24	..
9th	..	..	..	..	..	..	2D	..	21	..
10th	..	..	..	..	..	..	..	..	28	..
11th	..	..	..	..	..	..	..	..	30	..
12th	..	..	..	..	..	..	..	..	27	..
13th	..	..	..	..	..	..	..	..	11	
14th	..	..	..	..	..	..	..	..	14	..
15th	..	..	..	..	..	..	..	..	4	..
16th	..	..	..	..	..	..	..	..	D	..
Total number of eggs laid.	81	12	20	17	5	13	60	15	219	47

Note :—A denotes accidentally killed.
D ,, died.
E ,, date of emergence.
F ,, escaped.
Female No. 1 was caught from the fields on July 6th.

TABLE No. 2.

Table showing the length of egg stage of *M. lefroyi*. 1920.

Eggs laid.		Eggs hatched.		Duration of egg stage.
Date.	Hour.	Date.	Hour.	Hour.
13th July . .	13·48	14th July . .	11·40	22
14th July . .	9·10	15th July . .	7·50	22¾
	8·25		7·50	23½
8th August . .	9·0	9th August .	6·0	21
	7·0		6·0	23
4th October . .	17·45	5th October .	17·0	23¼
	11·35		11·40	24
5th October .	11·30	6th October .	11·45	24¼
	12·55		13·10	24¼
	11·20		11·45	24½
	17·0		17·35	24½
6th October . .	17·0	7th October .	16·55	24
	11·40		12·05	24¼
	10·0		11·20	25¼
	7·10		9·0	26
	8·15		10·15	26
	8·0		10·15	26¼
7th October . .	16·45	8th October .	17·05	24¼
	9·20		10·45	25½
8th October .	10·55	9th October .	11·50	25
	7·20		9·15	26
	10·55		13·35	26½
	16·35		16·38	24

Table No. 3.

Duration of larval stage of *M. lefroyi*. 1920.

Eggs hatched.		Grubs spinning.		Total Number of hours in larval stage.
Date.	Hour.	Date.	Hour.	
9th August	6·0	10th August	14·0	32
	6·0		19·0	37
4th October	18·0	6th October	13·10	33·10
	18·0		17·20	47·20
	18·0	7th October	8·30	62·30
5th October	9·20		5·50	44·30
	17·0		17·55	48·55
	9·20		17·50	56·30
6th October	17·35	8th October	16·50	47·15
	7·45		7·45	48
	7·40		7·45	48·05
	17·30	9th October	9·10	63·40
7th October	11·20		9·15	45·55
	16·55		16·55	48
	10·15		16·50	54·35
8th October	8·0		16·55	32·55
	17·0	10th October	9·0	40
	17·0		16·35	47·25
	17·5	11th October	10·15	65·10
9th October	11·30		10·20	46·50
	13·35	12th October	17·0	51·25
10th October	9·0		9·0	48
	16·35		17·0	48·25
	10·20		17·0	54·40
	16·35	13th October	10·30	67·5
	16·35		10·40	67·15
13th October	7·50	15th October	11·0	51·10
Grubs collected 19th December		28th December	10 days.	

TABLE NO. 4.

Duration of pupal stage of *M. lefroyi*. 1920.

Date of spinning.	Date of emergence of adult.	Total Number of days in pupal stage.
27th September	2nd October .	5
27th September	2nd October .	5
7th October	12th October . .	5
7th October	13th October . .	6
8th October	14th October . .	6
8th October	14th October . .	6
10th October	15th October . .	5
10th October	16th October .	6
11th October	16th October . .	5
11th October	17th October . .	6
11th October	15th October . .	4
12th October	17th October . .	5
12tn October	18th October . .	6
12th October	19th October . .	7
13th October	19th October . .	6
13th October	18th October . .	5
14th October	19th October . .	5
15th October	21st October . .	6
17th October	24th October . .	7
17th October	25th October . .	8
30th December	26th January .	27

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6. Pennington (1916). Journal of Economic Entomology, Concord, Vol. IX, No. 4, pp. 401-406.

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8. Lefroy (1906). Pusa Bull. No. 2, p. 5.

What proportion of the eggs hatched ?

Out of 219 eggs, only 62 hatched. They were all males. Parthenogenesis is common in this species and always produces males.

To obtain the parasites more easily, at Pusa we tried to discover alternative hosts. We found a number on lac insects and different caterpillars. What appears to be the same species is also parasitic on the Pink Bollworm, but the grub of the parasite is much affected by mites. Our observations here agree with Mr. Husain's. I have seen the parasite at the mouth of the hole in the boll made by the caterpillar ovipositing at the tunnel when it could not reach the caterpillar, so that when the caterpillar came out, the eggs stuck on to it, and hatched, and we reared adults from them. The proportion of parasitization is very low here. We have also raised a hyperparasite.

Do you think the hatching of the eggs of the parasite is correlated with light or heat ? What percentage of parasitized larvæ occur in the field ?

Hatching is probably correlated with temperature. We are now working out the parasitization percentage.

42.—KŒNIG'S PAPER ON SOUTH INDIAN TERMITES.

(Plates LII—LV).

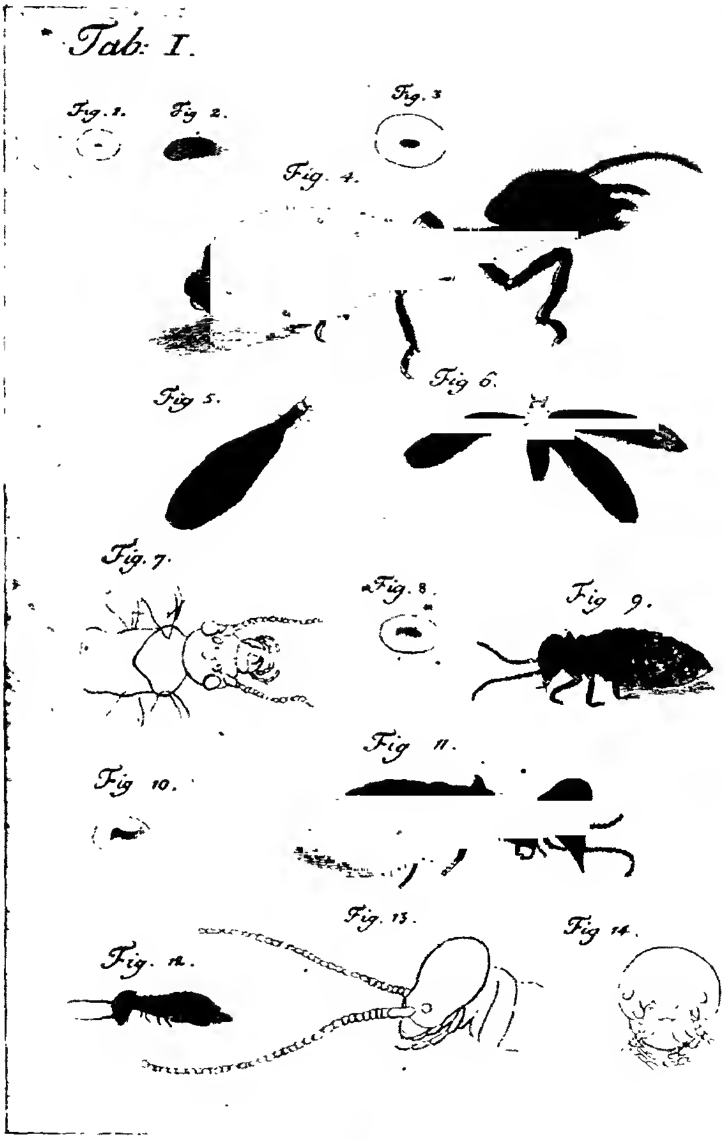
By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist.*

Introduction.

It is difficult to imagine what the writers of popular works on Natural History, until quite recently, would have found to say about the insects popularly called " White Ants " if they had not been able to draw upon the information furnished to them by Smeathman. " Some account of the Termites which are found in Africa and other hot climates," written by H. Smeathman from his own observations in the neighbourhood of Sierra Leone in West Africa, was published in the Philosophical Transaction of the Royal Society of London in the year 1781, and for over a century formed practically the only known and tolerably complete account of the habits of the wonderful insects known as Termites or White Ants. Smeathman's statements were copied and recopied by one author after another until it becomes a matter at once of amusement and monotony to compare the several authors' accounts with their original inspiration.

Many of Smeathman's statements were challenged as to their accuracy by his contemporaries and their successors during the next two generations until T. Savage published in 1849 his " Observations on the Species of Termitidæ of West Africa described by Smeathman," which thoroughly corroborated the observations made in the eighteenth century.

Yet, although Smeathman's observations have been claimed as the very foundation of the study of Termites, it is a fact (hitherto usually overlooked) that he was not the first to publish a series of scientific observations on these insects. That honour had already been achieved by Dr. Johann Gerhard Kœnig, who two years previously (in 1779) had published a paper entitled " Naturgeschichte der sogenannten Weissen Ameisen " [Natural History of the so-called White Ants] in the fourth volume of the " Beschaftigungen der Berlinischen Gesellschaft Naturforschender Freunde." Let us hasten to add that Smeathman's investigations were carried out entirely independently of Kœnig's and that he tells us expressly that he had not been able to procure a copy of the latter's paper and had seen nothing of it beyond a short abstract.



Kœnig's Plate of South Indian Termites.

From the time of its publication, indeed, up to the present day Kœnig's paper has remained practically unknown, and this has been due to the obscurity of the publication in which it appeared. It is probable that the Transactions of this Berlin Natural History Society appeared in the first place in a very limited edition and that the troublous times that succeeded on the Continent effectually reduced almost to vanishing point the small number of copies extant. Be this as it may, this Journal appears to be extremely scarce nowadays, and I myself have not been able to come across a single copy. So far as I am aware, no copy exists in India and the only copy in England is the one contained in the Library of the Royal Society of London. This copy has formed the original from which I have made my translation and I am extremely indebted to Professor and Mrs. Maxwell Lefroy for making and sending me a manuscript copy from this volume, and also to Professor J. Stanley Gardiner, F.R.S., for his kindness in obtaining a photographic copy of the plate which illustrated Kœnig's paper ; this plate is reproduced here as plate LII. Kœnig, of course, wrote in German, and his spelling and expressions are often difficult to follow from a modern viewpoint. In the translation which I have given I have endeavoured to give his meaning freely rendered into modern English and, where phrases are freely rendered or are at all doubtful in their meaning, I have usually added the original German in round brackets ( ). Words and phrases in square brackets [ ] are additions by myself in explanation of the text. I am much indebted to the Rev. J. Assmuth, S.J., for his kindness in reading over my manuscript and checking the translation.

To the Entomological Public, no apology is needed for bringing to their notice Kœnig's valuable and interesting paper which has remained in oblivion all too long. Nor do I think that any apology is required to readers in India who may not possess any special interest in Entomology. Termites, under the name of "White Ants," are known to every dweller in the East and all who have suffered from their ravages may well be interested to read this account of them written over one hundred and forty years ago and to find that the first reliable statement of their habits was based on observations made in Southern India.

A short account of Kœnig's life and work is added. So far as I am aware, no portrait of him is in existence ; if any reader of this is aware of one, I shall be glad to hear of it.

Note on Dr. J. G. Kœnig.

Johann Gerhard König, commonly called John Gerard Kœnig by contemporary English writers, was born at Lemenen in Courland

(Denmark) on 29th November, 1728.* We know that he was a pupil of Linnæus who commemorated his name by bestowing the generic name *Kœnigia* † on a curious little plant discovered by Kœnig during the latter's travels in Iceland in the year 1765.

The exact year in which Kœnig first arrived in India is not known with certainty but it was probably about 1767.‡ We know at least that, in a letter written to Linnæus from Tranquebar on 26 July 1769, he refers to another letter written more than three months before, but this former letter is apparently not now extant.

Kœnig apparently came to India, under the protection of the King of Denmark, as physician to the Danish settlement at Tranquebar.§ It seems probable, however, that he accepted this appointment mainly as giving him an opportunity of improving the, at that time, very scanty knowledge of the Natural History of India. Little is said in contemporary accounts of his medical duties, but we know that he resided for several years at Tranquebar where he applied himself indefatigably to acquiring a knowledge of Indian Plants. It is more than probable that he also made considerable collections of insects and that it is to his energies that we owe the long list of insects described from Tranquebar during the succeeding twenty years by Fabricius, with whom we know that Kœnig was in communication. He seems, indeed, to have paid some attention to every branch of Natural History, as we read of his giving assistance in mineralogy to Dr. James Anderson, who in 1795 was Physician General at Fort St. George. It is, however, as a Botanist that Kœnig is best known and all of his published writings deal with Botany, with the exception of his paper on Termites. Little is on record concerning Kœnig's life at Tranquebar but we can picture him performing the routine duties of Medical Officer in charge of that small Danish Settlement and devoting every spare moment to the acquisition of specimens and knowledge of that Natural History which he loved so well. Whenever his opportunities and finances afforded, he made occasional collecting expeditions from Tranquebar and thus visited the Dutch, French and British Settlements along the

* The place and date of birth are given by Hagen (Bibliotheca Entom. I, 428).

† Mantissa Linn. Gen. Pl. p. 13.

‡ Dr. Russell says "probably in 1768" Foulkes (*Madras Journal of Literature and Science*, No. 11, New Series—May 1861) says that Kœnig "had preceded Rottler in the mission by nearly ten years." Rottler arrived at Tranquebar on 5th August 1776.

§ In his "Biographical Memoir of Dr. Rottler", published in the *Madras Journal of Literature and Science*, No. 11, New Series—May 1861, the Rev. T. Foulkes notes that "besides [Kœnig] the naturalist, who was for a while the Medical Adviser of this Mission [the Danish Mission at Tranquebar], and not ordained, there was at the same time a missionary of the same name in holy orders at Tranquebar. In the documents that I have consulted the accounts of these two individuls seem to be hopelessly intermingled. The Clergyman died in 1795, after 27 years' residence in India."

Coromandel Coast and in all of them entered into friendly relations with everyone whose tastes were similar to his own. Dr. Russell, who met him in later years and who writes feelingly of his uniformly friendly relations with Kœnig, says of him at this period that, " More covetous of fame than of fortune, he persevered in his pursuits with an enthusiasm that set bodily fatigue, spare meals, and a scorching climate at defiance ; while the simplicity of his manners, and his unassuming readiness to impart knowledge to others, conciliated, almost at first sight, the benevolence of those with whom he conversed .... and everywhere he acquired friends."

The slender salary of his appointment at Tranquebar proved, however, quite inadequate to bear the expenses of his travels, however frugally conducted, in search of novelties, and in about the year 1774 Kœnig, by the influence of some of the many friends he had made during his wanderings, obtained an appointment as Naturalist to the Nawab of Arcot, in whose service he remained for several years, and during this period he made excursions amongst the hills near Vellore and Ambur, and to other localities which promised to yield novelties. Thus in April 1776, he made a short collecting expedition to the Nagori* Hills with Dr. George Campbell, a young medical man in the service of the East India Company and stationed at Madras, and who seems to have given proof of some talent as a botanist. His friendship with Kœnig, accentuated perhaps by their companionship during this excursion, appears to have kindled his enthusiasm into a resolve to devote himself seriously to the study of Botany, for shortly after this he sent to England for a large consignment of books on this subject : but, says Russell, " they never reached him ; for, being wounded, and taken prisoner, in the unfortunate defeat of Colonel Baillie's detachment, in September, 1780, he died a short time after, universally lamented."

During at least portions of the time during which he was in the service of the Nawab of Arcot, Kœnig resided in Madras and his intercourse with the English employed there in the Company's service seems to have gained him the friendship of all of them who took any interest in Natural Science. Many indeed, were glad to receive instruction from a pupil of the celebrated Linnæus, and amongst these are mentioned especially Dr. James Anderson, afterwards Physician General at Fort

* Dr. Russell (Preface to Volume I of "Coromandel Plants") says "the Pullicate Hills, in April 1766." The date is an obvious *lapsus calami* for 1776 as just previously he had given 1768 as the probable year of Kœnig's first arrival in India. The Pulicate Hills are evidently the same as the Palliacatti Mountains referred to by Kœnig (see page 31). Pulikat is on the coast a few miles North of Madras.

St. George, and Dr. Roxburgh, afterwards Inspector of the Botanical Gardens at Calcutta, who was then living at Samalkota.

It was probably during his residence in Madras that Kœnig had outlined a scheme for the investigation of the natural resources, not only of India, but of South-Eastern Asia, but this he was quite unable to carry out with his own slender resources, added to which his salary from the Nawab of Arcot was not paid regularly. Moved by these considerations, in 1778 he represented the facts of the case to the Board of the East India Company, which was pleased to grant him a monthly allowance "in order to enable him the better to prosecute his researches." "With this aid, he proceeded in the month of August 1778 to the Straits of Malacca and Siam; from whence he returned towards the end of 1779. From his report to the Board of Madras, it appears, that he had the good fortune to meet with several new subjects in Natural History, and to make some discoveries in Botany and Mineralogy, which he flattered himself might prove acceptable to the Public; particularly in respect to the article of tin ore ...... He intimated also his intention of sending to St. Helena, by the ships then on departure, the seeds of such esculent and other plants, and of such trees or shrubs as he had then got ready, and might probably be of use in that island" (Russell).

After his return from Siam he appears to have entered into a more formal Agreement under which he was to devote his whole time to the service of the East India Company, whose Board in Madras was pleased in 1780 to make an addition to his salary, which met with the approval of the Court of Directors in England.

In the same year (1780) he made a short excursion to Trincomali, in Ceylon, and early in 1781 a second excursion to Colombo. He must, however, have been in Ceylon before, as an earlier visit is noted in his paper on Termites published in 1779, and it was during this earlier visit that he met with *Eutermes monoceros*. As he notes (page 331) that this was subsequent to his trip to the Nagori Hills, which took place in April 1776, he must have visited Ceylon between this date and 1779.

The beginning of June 1782 witnessed the arrival in India of Dr. Patrick Russell, whose name survives to the present day throughout India in both the Scientific and English names of Russell's Viper, at once one of the best-known and most deadly of Indian Snakes. Kœnig and Russell met at Tranquebar, immediately after the latter's arrival, and at once formed a friendship and commenced a correspondence which lasted until Kœnig's death three years later. With his accustomed liberality Kœnig not only gave Russell a copy of his own list of the Plants of the Coast of Coromandel but also a number of specimens, as an inducement to the latter to interest himself in Indian Botany.

During the next two years we have no direct knowledge of Kœnig's movements or doings but it may be gathered between the lines of Dr. Russell's remarks that his health was beginning to show signs of becoming undermined by his strenuous labours in the Tropics during a period of upwards of twenty years. Dr. Russell tells us at least that he had hinted more than once that Kœnig ought to prepare his manuscripts and specimens, so that, in case of his death, they might be published, if possible by Sir Joseph Banks or at least under his auspices.

For some time Kœnig had been under a promise to pay a visit to his old friend Claud Russell, then Chief of the Company's Factory at Vizagapatam, and with whom his brother Dr. Patrick Russell was then living, and in 1784 he fulfilled this promise and stayed for a short time at Vizagapatam on his way to Calcutta. During this halt he examined and arranged a collection of plants made by Dr. Russell, who again impressed upon him the necessity of arranging his manuscripts, which he promised to do. But the eagerness with which he sought novelties during the journey and the claims of his work in Calcutta prevented this being done and, on his return to Vizagapatam in April 1785, he had not carried his good resolutions into effect "though the declining state of his health at that time rendered it more than ever expedient to prepare for an event which he himself appeared to consider at no great distance."

For two or three weeks he stayed with the Russells at Vizagapatam and during this period he seemed to recover his health to a great extent, and in May proceeded to Jagannathpur where he proposed to make an immediate commencement of the task of putting his manuscripts in order. But towards the end of the month he suffered a relapse of his former complaint (dysentery) under which he gradually sank until he expired on the 26th of June 1785 in spite of the skill and friendly attentions of Dr. Roxburgh, who was then living close by at Samalkota. On 6th June he had made his will by which he bequeathed all his papers to Sir Joseph Banks and a few days before his death he had seen all such papers as were then with him sealed up in the presence of Dr. Roxburgh, by whom they were afterwards despatched safely to Sir Joseph Banks; but others of his manuscripts, particularly those left at Tranquebar (including the Journal of his visits to Ceylon), were unfortunately not recovered, although Dr. Russell and Dr. Roxburgh did all in their power to obtain possession of them.

For many years Kœnig had maintained a correspondence with Linnæus and other European Botanists eminent at that time, and several of his communications to them regarding Indian Botany were published in the Transactions of the Societies of Copenhagen and Berlin, or included in the works of Retzius and other authors. Although it is certain

that he forwarded to Europe most, if not all, of the numerous insects described by Fabricius from Southern India, we know nothing of his direct interest in entomology beyond the present paper on Termites. Considering that absolutely nothing was known of the economy and habits of these insects before that time, his observations seem remarkably accurate and serve to show that Kœnig set an extremely high standard for his time as the first entomological observer who accomplished any scientific work in India. His paper seems well worthy of being rescued from the obscurity in which it has remained for over one hundred and forty years.

Translation of Kœnig's paper on termites.

In the first volume of the Proceedings of the Berlin Naturalists' Association on pages 177 *et seq* there is an excellent essay by Professor J. C. Fabricius concerning the designation of the castes of White Ants.

As I am now staying in a place where these animals actually have their home, both from that circumstance and through the persuasion of some friends in Madras, I have been induced to undertake some close observations, which I have the honour herewith to lay before the hon'ble Natural History Society of Berlin.

In order to be placed in the position to be best able to learn about these animals I picked out a place where they could not be obstructed in their work either by force or by want or by other circumstances and where their nests were to be met with in large numbers.

I found such a spot East-South-East from Tanjore (" Tanschaur ") where, at a distance of approximately half a German mile [*i.e.*, about 2½ English miles-T. B. F.], there is a high-lying level plain and almost limitless surrounding country of which the soil is formed of a deep-red clay which is mixed with a small quantity of coarse sand and, in various places, with some small fragments of Tufa (" Tophus ").

The scanty Flora there consisted for the most part of only : *Aristida arundinacea* ; *Saccharum spicatum* ; *Pharnaceum Mollugo* and *Ceronna ; Hedysarum nummularia, pulchellum, diphyllum, hamatum, biarticulatum* ; *Spermacoce hispida ; Viola fruticosa* and a new species of *Hegilops*.

Here and there grew a little *Riccia* where water had stood after the rains. On the whole plain there were otherwise no shrubs to be seen on the right hand, but to the left at some distance there were the gardens of a Moorish hermit and some other desolate places.

In this locality many hundreds of nests of these animals are scattered over the whole plain.

The area of ground which each nest covers is rarely more than three paces in diameter ; most are smaller, and their greatest depth below the

TERMITARIA AT TANJORE.

(Photographs by C. Narayana Ayyar).

TERMITARIA AT TANJORE.

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TERMITARIA AT TANJORE.

(Photographs by C. Narayana Ayyar).

soil is three feet. In flat and elevated ground, the chimneys, which they are wont to erect, are at the most two feet high ; but it is different if the ants build amongst bushes, on old stumps, or on the bunds ("Reinen") of the wet rice-fields ; as then their mounds rear up like old ruins to a man's height above ground-level. The number of these chimneys, which have more than one opening, is not so accurately defined ; however, there is rarely more than one principal chimney which is built up like a pillar ; the others are only low ones.

The principal entrances which lead through these chimneys into the earth to the separately constructed chambers of the nest ("abgetheilten Wohnungen") occur in various numbers and are quite irregular. At first they go vertically downwards, but divide as soon as they reach below ground-level into numerous small passages, and they are mostly round. In addition to these, the nests have now and then cavities which are at a lower level, and sometimes even quite small ones at some depth in the ground.

Each single nest is divided up into many chambers separated from one another ; but these are placed so irregularly that nothing definite can be said regarding their divisions. They are found approximately in three rows one below the other and the uppermost lies barely a foot below the ground.

Each single chamber forms a conical vault which is quite flat at the bottom and is rounded well-nigh spherically at the top. Their inner-surface is everywhere quite smooth and even and they are separated from each other by strong partition walls consisting of soil ("durch starke Zwischenraume von Erde getrennt."). The entrance to each chamber is found at one side, near the floor, and I have never found more than one ; these lead, as stated above, from the divided main-galleries.

Very rarely I have found that the upper chamber had a gallery through its floor leading to the lower chamber.

The height of a single one of the finished chambers is not above two-thirds of a foot, and in diameter it is somewhat more than half the height.

The semiglobular shape of its arch appears to be characteristic of it ; for this is invariably found in all newly commenced and small chambers.

Their dwellings [*i.e.*, the fungus-combs] have, as stated, the shape of the vault [in which they are placed] except that they are separated everywhere from the inside wall by a small interval ; also on the bottom there is not to be found the slightest trace that they are made firm somehow or other by an adhesive substance or by any other means.

They consist of innumerable intercommunicating passages, which are their cells, whereto most entrances enter from below, a few from above and fewest vertically. The shape of the holes of the entrances is usually round. The galleries broaden inwardly, in many places, yet the openings from one gallery into another invariably keep their nearly round shape. The walls of these cells are tuberculated (" knotigt ") on their outer and inner surfaces, like a shagreen-skin, and this is most distinctly noticeable on the edges near the openings and entrances. Through a magnifying-glass they appear fibrous and woolly. The thickness of these walls, if they are still recent, amounts to one-and-a-half and in most places barely one-third of a line. The inner part of these walls is composed of quite delicate filaments and small particles of clay fixed together by these animals by means of a cement contained in them, as is very plainly to be seen on fracture.

The colour of these nests depends for the most part on the quality of the soil in which they occur ; at Tanjore they were reddish, at Tranquebar I have seen them black. The greater age of a nest has also the effect of darkening its colour.

In the rainy season, when I took the cellular dwellings [fungus-combs] out of the ground, they were very fragile. A couple of hours afterwards they were harder, and on the second day, when I placed them in water, they floated so that a third of these dwellings remained above the surface of the water for more than twelve hours.

In water these cells [combs] do not melt but colour it a little brown and give it a somewhat bitter taste which contracts one's mouth.

When placed in a charcoal-fire, this substance burns with a strong smoke which seems to me to be of vegetable origin. It becomes red-hot without disintegrating, keeping the heat for a long time, and some specimens on touching them have given a kind of ringing noise, especially if overturned or dropped on the ground.

The queen-cell is always in the centre of the nest and always between the topmost and lowest stories of the cells.

It is a quite flat, horizontal vaulted chamber scarcely an inch high ; and its breadth is adjusted according to the length of the queen who inhabits it by herself. Rarely is she as long as one's finger. The walls and the floor are quite smooth and nothing more worth mentioning is to be found therein. The entrance to this cell, separated from all the others by thick walls of earth, is to be found at the side.

The neatness which I have observed in all these cells is the sternest that can be and I have been unable to discover anything uncleanly anywhere in them.

Just as little have I come across any provision for their maintenance; and that I never discovered any thing of this sort was, I concluded, probably for this reason, because the holes on the upper surface of the nest were closed up by the [washing action of the] rain and because they are smaller and narrower throughout than they are wont to be in summer.

Before I come to the description of the animals, I must mention a small plant which grows tolerably abundantly and invariably inside the walls of the combs ("Zellen"). According to Sir C. von Linné it will be a *Mucor* and is situated on a stalk bearing rounded composite snow-white bodies. It is very small and has quite a short stalk on which, as its fruit-part, the small head is to be found and this latter is composed of very minute globules and is of a snow-white colour. Here and there also, as if strewn, on the aforesaid walls there occur small, bent, white filaments which terminate sometimes in a small head, and sometimes are club-shaped.

May not a wise Providence have ordained these minute plants to grow here, perhaps for the immediate nourishment of the newly-hatched animals, whilst otherwise no nourishment is present in the nest nor can any foraging be done? This I only suppose; I have not observed it, because these young animals are all at once very feeble so soon as they come out of the ground into the open air and into daylight.

The inhabitants of these nests are firstly the males [workers T. B. F.]. Their head is for the most part oval, robust, flat, unequally beset with hairs; the neck is a little more elevated and rounded with [an anteriorly] projecting margin. The mouth is covered by a shield-shaped, rounded, superiorly convex, smooth fleshy membrane, which is sharp at the edge: and this is the upper lip. Over the root of this lip is a broad, heart-shaped, smooth, shining elevation which occupies the space between both antennæ ("Fuehlhœrnern").

The antennæ are composed of rounded joints, which are beset with outstanding hairs particularly at those places where they are joined to one another; they are also longer and darker than the head. There are no eyes but only a very small dark spot near the root of the antennæ, on the inner side.

At the angles of the mouth, on each side, is found a labial palp ("Fressspitze") which is bent crooked against the mouth. It is composed of four joints of which the outermost is lancet-shaped, flattened, bordered with short hairs along the edge and longest [*i.e.*, longer than any of the other three joints]; whereas the other three joints are rounded and the two innermost are quite short. Their whole length reaches up to beyond the mouth.

The upper pair of mandibles ("Fresszangen") is attached to the head behind the angle of the upper lip. Each mandible is thread-like, flattened, curved, inbent, horny, on the outer side thick, and rounded, on the inner side sharp-edged and furnished with several little teeth, mostly towards the base. Its upper side is level, shining black-brown, and not longer than the upper-lip.

The lower pair, whose roots go deeper into the head, are curvedly bent, thread-shaped, flat, thinner than the upper ones; on the inner side, before the tip, they have rather large teeth. The constituent parts, smoothness, colour length, are as in the upper ones. On either side of the mouth this lower pair of mandiles is covered with two mobile lips separated one above the other and these grow upon the roots of the mandibles. They are linear, flat, obliquely rounded at the end. The exterior margin is thick and rounded; the inner is made up of a thin membrane that is overgrown with fine hairs especially towards its tip, which [hairs] between each other are of almost equal length and as long as the mandibles ("welche unter sich fast von gleicher længe, und so lang wie die Fresszangen sind")

The lower lip is flat and split into six threads, which are somewhat pointed at the tip and of equal length. Both the outermost pairs are more rounded and bent towards the two inner, that are quite straight. The root of this lower lip only is short, level and of paler colour, beset with fewer hairs than where it is split.

The tongue is large, round, club-shaped, blunt at the tip, with a rust-coloured edge all round, and provided with a transverse line over the middle. Moreover, it is smooth and contains much mucus.

The thorax is rounded, composed of three sharply-defined annular, small segments, below which the legs are attached. It is much narrower than the head.

The abdomen ("Bauch") is oval, elongated and almost double the size of the forepart of the body. It has usually eight stumpy annular segments, sometimes more, and is strewn with upstanding hairs, especially on the sides where they seem to be longer.

There is nothing remarkable about the six legs; they are as long as the whole body.

The colour of the head is yellow, like amber, the remaining part of the body is whitish.

Next we remark the female, or the so-called queen. Her head, lips, antennæ, jaws, tongue and other parts are of like nature as in the male; only they are many times larger. Beside this, above the antennæ there are large, projecting, rounded, black eyes and ocelli.

The ocelli are situated on the inner side of each eye, transversely towards the forehead, and are longitudinal, enclosed, projecting, yel lower, shining dots.

The prothorax is usually flat, edged and somewhat serrated, overgrown with hairs, the mesothorax and metathorax are smaller and more blunted at both ends. They are, properly speaking, only supports of the wings. On each side of these segments anteriorly project a little the blunt ends to which were attached aforetime the wings whose roots stand out as triangular, mobile stumps.

The legs are formed as in the male but likewise larger.

The abdomen is barely the length and thickness of a finger and is contracted both above and beneath at seven almost equidistant places where an equal number of transverse marks are visible. These are linear, narrow, smooth, shining, of a yellow colour, and each extends over scarcely a quarter of the width of the abdomen.

The transverse marks beneath the abdomen are fainter. Between these transverse marks the skin is quite smooth, all the remainder of the skin is tuberculated, like fine shagreen, and milk-white in perfect specimens.

On each side of the abdomen are seven air-holes which have a like number of transverse openings. Each of these openings is longitudinal, bordered by a margin ; the hindermost are more rounded and smaller.

The anus is rather pointed and enclosed above and below by a pair of yellow transverse marks like scales such as have been mentioned before.

I have only engaged a little in anatomical researches on these animals. By means of a cruciform section I found that the tubular intestines occupy a small space below in the abdomen throughout its whole length, and the remaining area was filled by two cylinders which were as thick as a goose-quill and as long as the whole abdomen. Each of these cylinders was only attached to the general skin by a few filaments, but they had no connection with one another.

They are composed of numerous minute eggs, which are fastened to their particular ovaries which only consist of filaments and they are joined on very closely to one another. In the midst of them a strong tube extends lengthwise which is filled with something marrow-like of a darker colour than the rest. Can this be the nourishment for the eggs, or the seed for the fertilization of the eggs, or both together ?

Thirdly, are to be noted the young queens [evidently males which have shed their wings..T. B. F.] which have recently lost their wings and have the expectancy of being future queens. They are distinguished from the true queens by their abdomen being but slightly swollen

and by the transverse dorsal-plates ("Querstreifen") which are still contiguous and of a brown colour. At this time of year I found in each nest usually one, sometimes two, very rarely three, individuals of this modified form. Still at other times of the year, before they obtain wings, their number must be very large, since so many of them fly out. I only know them as individuals which have flown from their nest [*i.e.*, which have dropped their wings—T. B. F.], and at that time their four wings are club-shaped, on the outer side with a strong margin, rounded at the tip, veined, finely membranous, brown, of almost equal lengths, longer and many times broader than the whole body, which [wings] however, break off very easily near their base.

Fourthly, the soldiers ("Spadones")* remain to be noticed. In these the head is more flattened, narrower and more hairy than in the male [worker]; hence the neck is not so rounded off as in other cases, as is indicated by Sir C. von Linné's description of the head. They have only the upper pair of mandibles which are much longer and project much more beyond the mouth and are often crossed. Each of them is straight, slender, pointed inwardly; towards the tip it has a strong tooth, is narrow, horny, curved, bent inwards and also upwards, smooth, black, yellow near the base. In the lower lip the parts are all much shorter; but their [*i.e.*, of the divisions of the lower lip] base is larger and stretches further back towards the neck and is as if composed of three parts. They have, however, all the parts of the head as described for the male, only they are smaller; the abdomen is longer and more slender.

Young animals were abundant at this time. Those most developed are snow-white; the younger ones at the same time somewhat transparent. On the abdomen erect hairs are plainly visible. Because of their uniform white colour I could make no discovery about the eyes. They lived in the innermost combs of all the chambers.

The eggs are usually cylindrical, rounded at both ends, small, smooth, shining, milk-white, somewhat transparent withal, on one side rather more opaque. They were slightly fastened together one upon another, without order, on the walls in the interior of the combs; some of the large combs were filled full of them; their number was very large at this time of the year. By which of these animals they have been brought there [*i.e.*, into the combs] and how, I have not been able to observe.

The thorax is split up into three segments, whereof the midmost is adjoining the neck, whose end has an incision; both the other segments are divided above by a grove and small points project at the sides.

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* Castrated animals *i.e.*, neuters.

I also found, amongst these eggs, other much smaller bodies, compressed spherical, somewhat indented on one side by a small hole, smooth shining, and sometimes black, in quite small numbers. In some few nests I did not find them at all. Whether they belong to these or other animals, and whether they are also eggs, remains up to now quite unknown to me.

The people of Malabar call White Ants as a whole "Karreian" and their queen "Karrieian Tain," and the winged ones "Isel."

Remarks.

The time at which I have made the above-mentioned researches regarding these animals has not been the best for all purposes; yet it was not destitute of all benefit which amongst other things consisted firstly in this fact, that the clayey soil, softened by the rainy season at that time, was much easier to open up and therefore I have been able to remove all their combs (" Wohnungen ") unbroken, which in the dry months would have been far more difficult. Secondly, their nests were not so overcrowded with animals, so that I could investigate everything much better without being hindered by these animals; wherefrom it follows thirdly, that now that I know so much about them, I can continue my researches more correctly hereafter at other times of the year. I hope in the future to be able to communicate the results of my investigations to the Natural History Society, so far as they go.

Most of the accounts of the great damage, which these animals are wont to cause here, are rather exaggerated, like many other stories from India of which the strangeness has originated rather in the incorrect notions of their authors than from actual fact.

The golden-yellow spot on the forehead of the males, which Professor Fabricius has observed, is not to be found in my specimens, and neither (" eben so wenig ") are mine without a tongue which appears to be so necessary an instrument for their work, wherefore I conclude that the former [*i.e.*, Fabricius'] is another species.

But certainly I have found at various times certain lice very firmly affixed to their heads and these were convex like the genus *Coccinella*, but very small, and at the same time smooth, shining and yellow; as soon as I pressed them hard with a needle, they stuck out their head and feet and made off.

The number of males [workers] was at this time only quite small, also even in the queen-cell I found more soldiers. According to my observations I take them to be blind, at least they appeared to be so at the time, when I made my investigations; and one can scarcely believe

that this sense-organ should be so hidden in them that more could not be found out about it in fully-developed individuals. For the rest I acknowledge that of the changes consequent upon their age up to their death too little is still known to me.

There is invariably only one queen in each colony (" Wohnung ") rarely are there two in one nest, and these live in different stories ; very rarely are three found. This number applies also to the young queens [true males—T. B. F.], that have only small accessory cells (" Nebenlœcher ") to live in. Such a queen into which the soldiers have bitten quite firmly, I have preserved in spirit.

The attendants upon the queens, as stated above, are mostly soldiers, so far as numbers are concerned. I do not know their exact functions. But it happened to me in the case of several nests that when I removed the queen from her cell, these soldiers have clung onto her and onto my hand and have bitten so far into the skin that they perforce remained sticking therein. When the queen is removed from her cell, she is very soft and flabby, and lets at once a thin sticky moisture flow from her. As soon as she is placed in spirits of wine, her body becomes harder and her colour much whiter especially if she is still young.

Through the effects of age their skin becomes harder, and I have found some full of small abscesses and holes in their dorsal skin which is quite blackish.

In such nests where I found individuals like this I was also certain that I was bound to find young queens [males or kings] so long as these [old queens] still lived in them.

I have also often found empty nests in which not a single one of these insects was to be found and I believe that in these the queen must have perished and that no young ones had returned from their flight or remained at home, in consequence whereof the others had either deserted the nest or had died out also.

I know of no special enemies of the queen that might endeavour to disturb her in her cell or to kill her. The entrance into her cell is only as broad as a straw-stalk and passes through a strong wall of earth, so that neither can any moderately large animal get at her easily nor can she come out. I have found some few house-crickets in the earth near the cells ; but it was not possible for these to enter the small holes of the ordinary chambers (" Zellen ") and consequently still less into that of the queen. The *Kuli*-classes (" Arbeitsleute ") of this place, it is said, as soon as they come across a queen by chance through the breaking down of old buildings constructed of earth or in other places whilst digging, at once swallow her alive ; with the idea that it strengthens their spinal (" im Rucken ") nerves and gives great vigour. I have

not seen this myself; but I believe it to be true since I have been able so rarely to obtain them [*i.e.*, specimens of queens] near Tranquebar.

I have already said something concerning the greatest number of young females in each nest. Now I will bring forward my proofs [that they are indeed young females—really males]. Firstly, the large eyes, which all these have which have swarmed. Secondly, the special build of the thorax. Thirdly, the two accessory plates which are the supports of the wings. All these they have in common with the queens; but in the males [workers] and soldiers these parts are altogether lacking or are quite differently shaped. That the [young] queens [*i.e.*, males] themselves have been winged is proved by the stumps still remaining on the wing supports. Notwithstanding there are still other characteristics, I think that these will be quite sufficient.

They fly out like other ants. The time of their swarming out is various. Most usually and abundantly they swarm shortly before the monsoon rains. In somewhat smaller numbers before the Little Monsoon, that is, in April or May, after the first few showers. I have also found them flying out in other months in June and July after a few showers, but only in quite small numbers.

The evening, when it has become quite dark, is the proper time for them to leave their nests, and at times they occasion the Europeans some inconvenience through flying into their faces and into lighted lamps. But hardly does the sun shine on them in the morning, than they break off their wings; whereupon various birds and a few kinds of lizards and frogs on a day of this kind enjoy an excellent banquet which stand them so much the more in good stead, because some of them have to undergo a strict fast on account of the rainy season which follows shortly afterwards. This, then, is a great benefit for these animals given to them by the wisest foresight of our beneficent creator in order that they may better endure the, to them, calamitous times which follow.

I think that I have clearly shown above that these individuals which fly out, are only females; but whether they have been properly fertilized before their flight so that they are in a position to start new nests for themselves by their own effort or whether they go in quest of males, wandering short distances from their former nests and attract them [*i.e.*, males] to themselves with such an intention [*i.e.*, of starting a new nest ("in solcher Absicht zu sich leitten"); this I cannot tell for certain. Yet I am inclined the more to the former opinion, because their abdomen is already rather distended, and because the latter theory would also involve more difficulties.

The number of flying White Ants of this kind is usually large; so that from one nest if they have been driven out and caught in pots by people

who occupy themselves with this matter, almost a bushel-full can be collected. But this number is not always so large; for the locality, the time and the age of a nest makes some difference thereto.

Though it clearly appears from the foregoing that Providence has ordered the flight of the White Ants for the advantage of some animals; yet man even envies them this godsend, for he has found means to forestall them [*i.e.*, the other animals] to provide himself likewise with a kind of food composed of these fugitives before they fall a prey to these animals and even before the proper time of their flight has arrived.

With this object * the inhabitants of these parts, towards the end of the month of August or in September, erect over their nests little huts of basket-work which are closed above with a round arch of such a size that it extends over the breadth and height of a nest. These they cover quite thickly with clay; at the base they make a round opening which principally [as the main point] has a position coinciding with that of the principal entrance into the nest, so that they can apply and fasten a large jar about as big as a bucket, with a mouth a hands breadth across, which covers the hole in the hut. Then they let the hut

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* The procedure, as carried on in the Coimbatore District at the present day, is very similar but differs in details, At Coimbatore the emergence of the winged Termites is said to occur as a rule after the first rainfall in the Tamil month of *Audi*, corresponding to July.

At this time of year the professional Termite-catcher (known as a *Valayan* in these parts) selects a suitable mound, slices off the top level with the ground and pours water over it. A framework in the shape of a small domed hut is then built over the mound and composed of twigs and small branches of the *Babul* (*Acacia arabica*) or some other tree, and this framework is then covered thickly with leafy twigs, preferably of the Persian Nim Tree (*Melia Azadirachta*), though why this is preferred to others is not stated; it is used probably because the Persian Nim is a common tree hereabouts. A small opening of a size sufficient to admit the *Valayan's* hand, is left in the framework (Plate LV, fig. 1), though this also is ultimately closed up with leaves. Close to this opening and about the centre of the mound is excavated a pit about a foot deep and twelve inches in diameter and the mouth of this pit is narrowed by placing leaves of *Calotropis gigantea* (Tamil *Yerukam*) around it. (Plate LV, fig. 4). The inside of the pit is smoothly plastered with mud and it is then about half filled with water. Or sometimes an earthenware pot is buried in the pit and this is half filled with water. Everything being now in readiness, the *Valayan* takes a small quantity of a powder made of equal proportions of the roots of *Tephrosia spinosa*, Pers. (Tamil *Molkolingi*) and the seeds of *Erythrina indica* (Tamil *Mulmurungai*), baked and powdered together, and blows this powder into one of the main galleries exposed by slicing off the top of the nest. This powder is said to cause the Termites some inconvenience and to hasten their emergence. Having blown the powder in, the *Valayan* lights a small lamp and places it by the side of the pit, and then closes up the hut with leaves. The winged Termites fly out and fall into the water contained in the cavity, in which they are collected.

A reasonably good catch is said to yield as much as two Madras measures (of about 3 lbs. weight each) from a single termitarium. After collection the Termites are dried in the sun, when their wings become detached; in this state they are sold in the local bazaars at a price of about four annas for a Madras measure, but they are only available in the bazaars at this particular season of the year. They are eaten raw mixed with parched ("popped") paddy. Only the lower castes eat this food; one eighth of a Madras measure being as much as is usually eaten at one time; more than this quantity induces dysentery. I have, however, been unable to hear of any case of death caused by over-indulgence in this food, which is said to be both delicate and nourishing. T, B, F,

Fig. 1.—Termitarium arranged for capture of winged termites, Coimbatore, showing completed structure built over the nest.

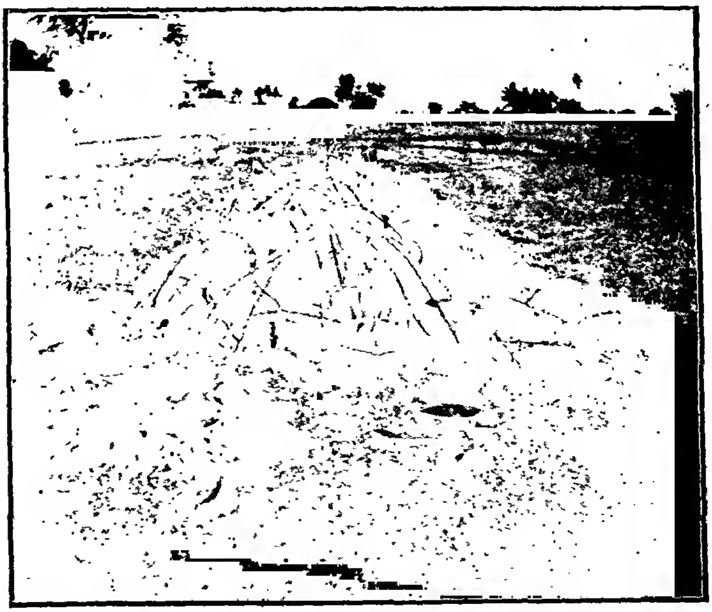

Fig. 2.—Outer layer of leafy twigs removed to show construction and internal pit for capture of termites.

CAPTURE OF WINGED ADULT TERMITES FROM THE NEST IN SOUTH INDIA.

(Photographs by T. Bainbrigge Fletcher).

Fig. 3.—Another view of figure 2.

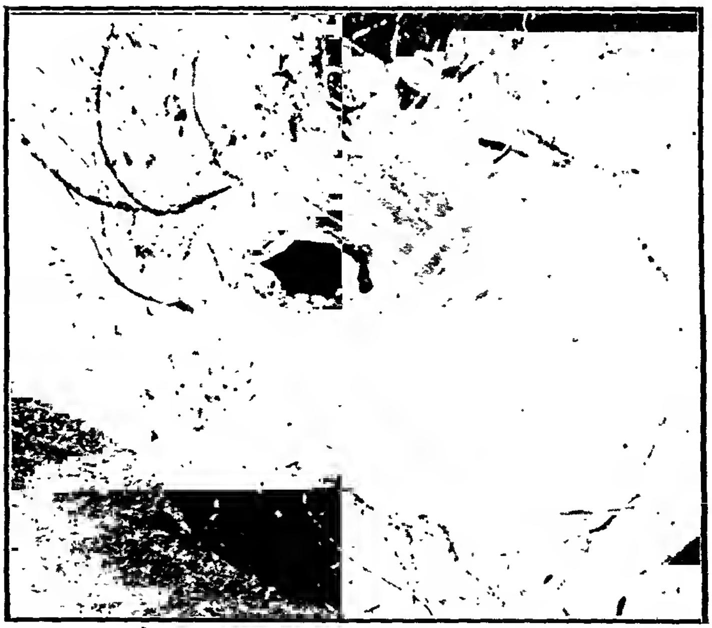

Fig. 4.—Nearer view of pit shown in figure 2 ; the entrance of the pit is encircled with *Calotropis* leaves.

CAPTURE OF WINGED ADULT TERMITES FROM THE NEST IN SOUTH INDIA.

(Photographs by T. Bainbrigge Fletcher).

dry, so that the clay becomes fairly hard. When they have now decided upon the time that seems best they place in the attaching jar some leaves of aromatic plants, amongst which deserve to be noted particularly the leaves of *Bergera,* which in Tamil is called "*Karu-Wapu-Ilei*" and is held in greater esteem by the natives of these parts than in Europe the leaves of the laurel. Some also take a little of the so-called *cocŭs,* or else Palmyra juice, which they pour therein. Then they fasten the jar to the opening of the hut so that absolutely none of these insects can fly out at the sides but all must fly into the jar. They wet the earth around the hut with water and then in the evening they make a fire round about the hut. Others will only do this on one side and think that the light of the fire communicates itself to them, whereupon they come flying out. Others again make on the side oposite the abovementioned opening a hole which also leads into the principal gallery of the nest, through which they, from a weak fire lighted before the hole, blow the smoke into the nest, and thus attract the winged ones of this community or forcibly compel them to premature flight. As soon as the draught [of the smoke] commences, they are also ready for it [*i.e.*, flight], and in quite a short time the jar is filled with these insects which the duly-appointed people then take away, and another jar, ready prepared like the first one, is quickly applied. This they continue to do until no more come flying out. So it happens that from large nests they obtain three or four such jarsfull. But those who attend to the jar must be careful not to get in the jar, instead of the flying White Ants, a *Coluber naja,* or in Portuguese "Cobra de Capello," which is said to be very enraged under such conditions because it finds itself in peril. They then proceed to kill ("suchen zu tœdten") those of the captured White Ants that are not yet suffocated; then they spread them out on mats and dry them in the sun and clean them of their wings. Some of them they roast forthwith and eat them at once without further preparation. I noticed that during the roasting they gave out some greasiness. Others are eaten together with roasted rice. But the greater portion of them are ground up and mixed with flour of various edible kinds of grasses found in this country, such as *Holcus spicatus* or *Paspalum scrobiculatum, Cynosurus coracon, Cynosurus auratus* and many others. From this paste are baked cakes which in some localities, in places where these Ants occur commonly, are sold in the bazaars. But only the lower castes of the Malabaris eat this food out of wantonness ("aus Uebermuth"); but sometimes as a sovereign remedy ("Heilmittel") in some sorts of wasting sicknesses. The poor are those who make most use of these means of nourishment on account of the moderate price. Excessive indulgence in this food induces a

choleraic (lit. apoplectic, " Bauchschlag fluessig ") dysentery so that they die of this sickness in one or two hours.

I have still to remark as something quite peculiar that the greatest number of these insects stay in such places where little or no rice is harvested ; but where the above-mentioned cereals are most cultivated, which is invariably done on the high-lying, dry fields.

Why the soldier's mandibles are curved upwards, I do not know. They are thereby inconvenienced because, when they bite into soft bodies, they [the jaws] go crosswise over one another and they [the soldiers] must remain attached thereto, for it is not possible for them to disengage themselves on account of the curve of the mandibles :— their abdomen is then erected vertically upward away from the locality of the bite. Perhaps they remain on this account hanging so fast, partly so that their enemies cannot so easily free themselves, partly so that they, because their bodies stick out so when biting, block the enemy's passage through their extension [into the thoroughfare.] Both males [workers] and soldiers are as if confused and dizzy and die in a few minutes if they come into the full glare of the sun entirely without shelter; and the true Ants are then very busy in satisfying their hunger with them.

Herewith, for the present, I think I have said sufficient about the so notorious species of White Ant. To this I will add my suppositions about a few other kinds and will close [my account] with a [note on one which is undoubtedly a truly] distinct species. (" einer wirklichen Art.").

The first * probable [*i.e.*, presumably distinct] (" vermuthlich ") kind of these insects lives together in small societies on footpaths in grassy localities, and usually direct their track obliquely over and near small paths. They build no mounds (" Gewœlbe ") over themselves, like the foregoing ; their body is several times larger and they are also proportionately much stouter. I have as yet not had the opportunity of making more exact observations as they are very scarce and I have also found them only in out-of-the way (" unwegsam ") places. The Tamils call them the Finger-post (" wegweisende ") Ants.

A second probable species I have found in the jungle under large trees, running over dry leaves in very long processions as broad as one's finger. These are almost as long as a finger-joint, and blackish-grey, and I discovered them in the following manner : On one of my journeys, when I was travelling through a grassy jungle (" Grasswald "), and it was just mid-day, I took refuge under the trees because of the great heat. My eagerness to discover novelties soon led me away from my men, and thereupon I heard a peculiar continuous rattling whose cause was un-

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* *Hodotermes viarum*, Kœnig; the worker is shown on Plate LII, figures 12-14.

known to me. After much looking around I retreated a few paces that I had advanced during the [continuance of the] sound and then I heard this noise again. Then I most carefully paid every attention and saw this kind of White Ant under my feet and when I repeatedly interrupted their line in various ways, I observed that, in eases where they were disturbed, they raised up their bodies a little, and with a vibratory movement thereof (" mit einer Federkraft damit ") struck downwards again with their horny mandibles on the dry leaves. By this means was occasioned this rain of blows of the large continuous crowd. Precisely this, upon my narrative, has an English Captain, Herr Cotgrave, of the Tanjore Garrison, quite recently put to the test also in a jungly place. Meseems that these insects ought to be named *Convulsionarii.*†

I now close my review of these insects with a third and undoubtedly distinct species which I have only come across in desert places (" Wuesteneyen ") in two localities widely separated from one another. Firstly, I found them on the summit (" Rucken ") of one of the so-called Palliacatti Mountains,‡ called Nagori, at the foot of a rock-fissure [from which was] projecting a small portion of the nest of which, as well as of the insects, it was only possible for me to collect a small sample. The rock was moderately overgrown with *Byssus antiquitatis.* And even the little I had obtained I lost in going down from this very high mountain, as I found myself between two and three o'clock in the afternoon in thick undergrowth where there was no breath of wind and the temperature nearly 34 degrees above zero on the Reaumur scale [108·5 Fahrenheit], whence I fell down exhausted with the usual consequences (" und die Folgen davon hatte, die dabey gewohnlich sind,"). Under more fortunate circumstances I found them * for the second time in Ceylon, where I ....[? omission in text] through the so exceedingly kind assistance of Commander Christian Rose, who, besides being himself a scholar, is at the same time also a great promoter of the aims tending thereto and has shown himself such especially towards me. To

† *Termes convulsionarius*, Kœnig. This species is not shown in the Plate which accompanied Kœnig's paper but his description of the size, colour, and especially the habits of his species can leave no doubt as to its correct identification in the mind of anyone who has encountered the wonderful processions of this Termite. A full description of its bionomics and structure is reserved for another occasion and it will suffice to note here that this is the same species which was redescribed by Desneux, more than a hundred years later, under the name of *Termes esthcræ* (Ann. Soc. Ent., Belge 1907, p. 390). T. B. F.

‡ The Nagori Hills, some 40 miles North-West of Madras City, are perhaps referred to. See page 315.

* The species found in Ceylon, *Eutermes monoceros*, was undoubtedly distinct from that found by Kœnig in the Palliacatti Hills, as *E. monoceros* is not known to occur in India. *E. monoceros*, Kœnig, is shown in Plate LII, figures 10, 11 (Soldier), and these figures must have been drawn from Sinhalese specimens, as Kœnig evidently implies in the text that he lost the specimens collected in the "so-called Palliacatti Mountains." T. B. F.

mention but one instance, I was accompanied free of charge to the jungle where the Dutch Company has their large wood-cutting place (" Holzhauerey ") [*i.e.*, place in the forest where trees are felled.]. There I found, amongst a number of undetermined things in Natural History, these insects also, in several nests in hollow trees, most of which were of very tall growth (" hochstammigt ") and not so easy to reach. The most conveniently situated [for taking down] and largest nest amongst these was hanging forward, on a large bough of a very thick tree, which is called "Kotu-Moil-Elou" in the *Hortus Malabaricus*, Part V, page 3, Table 2, and is a new species of *Vitex*,* Linn. This bough, which was as stout as a man, I had cut off two ells lower down, close to the trunk itself, with the object of finding perhaps, the queen of the nest; but my plan did not succeed. I found only that in this space the galleries of these insects were flatter and their divisions leaf-like, and these were stuck together out of small, longitudinal, smooth, inwardly and outwardly coal-black particles, among which a little sand and earthy matter was mixed. When thrown into a charcoal-fire, a fragment of this nest exudes before burning a black-brown oily moisture. The smell of the burning is vegetable, the ash white, and the specimen crumbles away of itself. On pulverising these crumbled ashes, one then finds the little earthy material [which the fragment of the nest originally contained]. A specimen of the nest placed in spirits of wine imparts to it a greenish colour and a mossy odour: but it does not thereby become more fragile. Still, I think that the black colour of these nests is mostly caused by the insect; although at the very beginning I supposed that they had their colour from the *Byssus antiquitatis*; but here in these forests I looked around for that and noted down all the mosses growing on the trees here. Very rarely I found *Lichen scriptus, sanguinarius, fusco-ater*, and others, from which the black colour might be expected. More commonly, I found white-grey lichens and red-coloured ones, but *Byssus antiquitatis* was not to be seen at all.

Concerning the insects themselves, it is not their peculiar blackness and differently constructed nests which I have taken as the distinguishing characteristics of a distinct species; but their differently shaped mandibles, their spherical necks † (" geballeter Nacken "), and the obliquely depressed, pointed, moderately large horn on the forehead of the soldiers; and this will be sufficient to distinguish them from the others. From this point of view I have taken them for a new species of horned White

* Vitex pubescens, Vahl.

† The word "neck" here evidently refers to the posterior portion of the head itself and not to the junction between head and thorax. See Plate LII, figures 10 and 11.

Ants whose black colour is at the same time their particular characteristic ; since, however, my leisure has not allowed me to investigate them further and since I have not been able as yet to come across the queen, this remains deferred until the future.

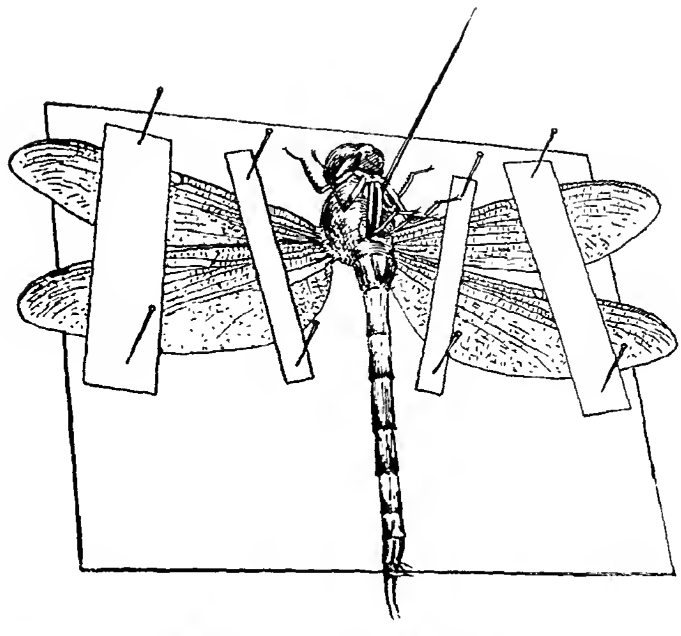
Should anyone wish to improve on my observations, I shall be glad to acknowledge this and beg him to authenticate any corrections under his own name. My circumstances have hindered me greatly in observing with precision ; and, if I myself should find any errors, I shall be ready to point these out with all sincerity in the future.

43.—SETTING WITHOUT BOARDS.

(Plate LVI)

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist.*

At our last Meeting, in a paper on Collecting Insects, I described a method of rough-and-ready setting of such insects as grasshoppers by the aid of small pieces of card through which the pin of the specimen is passed and on to which the wings are pegged out with small pins. Such a method was not intended to supersede the use of setting boards and was only meant to be used for occasional specimens when travelling. It has also the obvious disavantage that it is only applicable with any success to small insects in which the height of the thorax (or, more exactly, the vertical distance between the lower surface of the thorax and the lower surface of the wing) is inconsiderable; where this distance is appreciable, as in a medium-sized or large dragonfly, the wing is distorted downwards where it is pegged or braced onto the card, the result being that the surface of the wing is not flat, as it should be. This difficulty can be overcome very simply by setting the specimen with the upper surface of the wing braced down to the card. The procedure is quite simple and success is easily attained with a little practice. A piece of thin card or moderately thick glazed writing paper is cut to the approximate size of the extended wings and on one corner of this are written the data for the specimen. The pin for the specimen is then passed through the card up to the height at which the specimen is to be pinned and the point of the pin (which is grasped by its head with the forceps) is passed downwards through the thorax of the insect, which is then pushed up on the pin until the upper surface of its thorax is squarely against the card. The pin is then grasped point upwards with the left hand and held alongside the edge of a sheet of cork so that the wings on one side (with the card beneath them) project over and are supported by the cork. It is now easy to extend the wings and to brace them down with paper strips pinned into the card, still supported by the cork. When both wings on one side are spread out, there is no difficulty in removing the card from the cork, leaving the brace-pins sufficiently firmly attached in the card. The other pair of wings is then set out in the same way, if required. The specimen is now pinned into the top of the store-box, so that when the box is closed the specimen is upside-down and the body tends to lie flat on the card, which bears the data



SETTING WITHOUT BOARDS.

A dragonfly pinned onto a card, showing method of setting. The *data* are written on the other surface of the card.

on the exposed side. When ready for removal, the small pins attaching the braces are removed, the card mount pulled upwards over the head of the pin, and the corner with data cut off and attached to the pin below the specimen.

I have used this method quite successfully in the case of Odonata, Neuroptera, Orthoptera and large Lepidoptera and can recommend it for use when travelling and proper boards are not available.

44.—A CHECK LIST OF COCCIDÆ OF THE INDIAN REGION.

By T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S., *Assistant Entomologist, Madras.*

Recent publications on Oriental Coccidæ have shown how our knowledge of this group of insects has increased considerably within the last decade, in spite of the fact that only very few people have done any work in that direction. Apart from the value of the systematic study of this group of insects to Science, both Agricultural Entomologists and enlightened farmers have begun to realise the importance of scale insects from an economic aspect; this will be realised all the more as the fruit industry develops in India, since many Coccidæ are pests of fruit trees. It is therefore quite likely that greater attention may be paid to these insects in the future. In the course of my studies of the South Indian species of this family during the last three years it often occurred to me that a check list of the Indo-Ceylonese forms might be useful in various ways especially to workers in this group all over India and this paper is an attempt in that direction. No pains have been spared to make the list as up-to-date as possible by including all forms recorded or noted from this region till now; but all the same it is inevitable that some mistakes or defects must have crept in. I shall be very glad to have my attention called to any omissions that may be found out by other workers in this line.

The geographical area which this list is intended to include comprises the whole of British India, Burma and Ceylon.

In this connection it must be stated that no one has contributed to our knowledge of Oriental Coccidæ as much as Mr. E. E. Green, one of the foremost authorities on this family of insects; and amateurs like me working on this group in India owe him a debt of gratitude for the valuable help he has been rendering in this direction.

The information attempted to be given under each species includes one or two important references, one or two of the host plants, and the chief localities in the region where the insect was noted; under none of these heads is any attempt made to give complete information.

Explanation of abbreviations used to denote bibliographical references in the list.

Amer. Natur.—American Naturalist.

J. A. S. B.—Journal of the Asiatic Society of Bengal, Calcutta.

B J.—Bombay Natural History Society's Journal, Bombay.

I. M. N.—Indian Museum Notes, Calcutta.

E. M. M.—Entomologists' Monthly Magazine, London.

Spol. Zeyl.—Spolia Zeylanica, Colombo, Ceylon.

Bull. Ent. Res.—Bulletin of Entomological Research, London.

Pusa Mem.—Memoirs of the Department of Agriculture in India, Pusa, Entomological Series.

Pusa Bull. 87.—Bulletin of the Department of Agriculture in India, Pusa, on Coccidæ of South India, by T. V. Ramakrishna Ayyar, 1919.

Zt. f. wiss insect.—Zeitschrift fur wissenschaftl. Insektenbiologie.

Arc. Ent.—Arcana Entomologica (Westwood).

Hand. Ent.—Handbuch der Entomologie (Burmeister).

P. Z. S.—Proceedings of the Zoological Society of London.

T. E. S.—Transactions of the Entomological Society of London.

Gard. Chron.—Gardener's Chronicle.

Trans. Linn. Soc.—Transactions of the Linnean Society—Zoology.

Rec. Ind. Mus.—Records of the Indian Museum, Calcutta.

C. of C.—Coccidæ of Ceylon by E. E. Green, 4 Vols., London.

Ind. For. Mem.—Indian Forest Memoirs.

Imp. For. Bull.—Imperial Forest Bulletin, India.

Jour. Ec. Biol.—Journal of Economic Biology.

New Zal. Trans.—New Zealand Transactions.

Mon. Br. Cocc.—Monograph of British Coccidæ by Newstead, 2 Vols., London.

Ent.—Entomologist.

Proc. Ac. Nat. Sc. Phil.—Proceedings of the Academy of Natural Science, Philadelphia.

MONOPHLEBINÆ.

Monophlebus, Burm.

M. atripennis, Burm., p. 80, Hand. Ent., II, 1835.	...	...
M. atripennis, Westw., p. 22, Arc. Ent., I, 1841.	...	...
M. burmeisteri, Westw., p. 22, Arc. Ent., pl. 6, Fig., Fig. 2, 1841.	...	...
Drosicha burmeisteri, Ckll., p. 223, Ent., XXXV, 1902.		
M. saundersii, Westw., p. 22, Arc. Ent., I, 1841.	...	...
Llaveia saundersii, Ckll., p 318, Ent., XXXV, 1902.	...	...
M. leachii, Westw., p. 22, Arc. Ent., I, 1841.	...	...
Drosicha leachii, Ckll., p. 223, Ent., XXXV, 1902.		Malabar; Pondicherry.
M. zeylanicus, Green, p. 6, I. M. N., IV, 1896.	On *Antidesma bumius*.	Pundaluoya, Ceylon.
Kuwania zeylanicus, Ckll., p. 258, Ent., XXXV, 1902.	..	...

M. stebbingi Green, p. 100, I. M. N., Vol. 3, 1903.	On *Shorea robusta* .	United Provinces.
M. stebbingi, Green, p. 16, Pusa Memoirs, II, 1908.	.	
M. dalbergiæ, Green, p. 101, I. M N., Vol. 3, 1903.	On *Dalbergia sissoo*	Punjab.
M. stebbingi, Green, var *octocaudata*, Green, p. 16, Pusa Memoirs, II, 1908.	On Mango . .	Lahore.
M. stebbingi, Green, var *octocaudata*, Lefroy, p. 111, Pusa Memoirs, II, 1908.	On *Ficus* spp. .	Pusa.
M. tamarindus, Green, p. 17, Pusa Mem., II, 1908.	On tamarind . .	Agra.
M. tamarindus, Green, Ramakrishna Ayyar, p. 48, Pusa Bull., 87, 1919.	On garden crotons .	Godavari district.

Walkeriana, Sign.

W. floriger, Walk, p. 205, Cat. Brit. Mus. Suppl., 1858.		
W. floriger, Green, p. 6, I. M. N., IV, 1896.	On *Litsea zeylanico* .	Pundaluoya, Ceylon
W. compacta, Green, p. 6, I. M. N., IV, 1896.	On unknown plant .	Kelani Valley, Ceylon.
W. euphorbiæ, Green, p. 6, I. M. N., IV., 1896.	On *Euphorbia antiquorum*.	Hambantota, Ceylon.
W. senex, Green, p. 6, I. M. N., IV, 1896 .	On *Dodonea viscosa* .	Chilaw (Ceylon).
W. poleii, Green, p. 6, I. M. N., IV, 1896 .	Do. . .	Do.
W poleii, Green, p. 19, Pusa Mem., II, 1908.	On unknown plant .	South India.
W. pertinax, Newstead, p. 197, P. Z. S., 1900 and p. 125, Bull. Ent. Res., VIII, 1917.	...	...
W. pertinax, Newstead, Ramakrishna Ayyar, p. 48, Pusa Bull., 87 (1919).	On unknown plant .	Bangalore (South India).
W. cinerea, Green (*Nom nud*), p. 18, Pusa Mem., II, 1908.	On *Acacia arabica* .	Surat (Bombay).
W. cinerea, Green, Ramakrishna Ayyar, p. 49, Pusa Bull., 87 (1919).	On Sandal wood, *Lawsonia alba*, *Thespesia populnea* and Pomegranate.	South India.
W. xyliæ, Green, (MS.)	On *Xylia* . .	In North Malabar (South India).

Stigmacoccus, Hemp.

S. (Perissopneumon) ferox, Newstead, p. 250, Ent. M. M. XXXVI, 1900.	In nests of the ant *Oecophylla smaragdina*.	Konkan (Bombay).
S. (Perissopneumon) ferox, Newstead, Green, p. 19, Pusa Mem., II, 1908,		

Icerya, Sign.*

I. seychellarum, Westw., p. 830, Gard. chron., 1855. *I. tangalla*, Green, p. 7, I. M.N., IV, 1896. *I. seychellarum*, Westw., Ramakrishna Ayyar, p. 49, Pusa Bull., 87, (1919).	On *Cassia tora*, mango, casuarina, etc.	Bellary, Madras.
I. ægyptiaca, Douglas, p. 79, Ent. M. M., XXVI, 1890. *I. ægyptiaca*, Ramakrishna Ayyar, p. 49, Pusa Bull., 87, (1919)	On *Artocarpus* spp. Croton, *Ficus*, etc.	Widely distributed.
I. pilosa, Green, p. 7, I. M. N., IV, 1896.	On a sp. of grass near sea-shore.	Chilaw (Ceylon).
I. pilosa, Green, p. 18, Pusa Mem., II, 1908.	On *Spinifex squarrosus*.	Madras.
I. crocea, Green, p. 7, I. M. N., IV, 1896 .	On *Citrus*, croton and *Cocculus*.	Pundaluoya (Ceylon).
I. formicarium, Newst., p. 169, Ent. MM., XXXIII, 1897.	In ants' nests .	India.
I. minor, Green, p. 17, Pusa Mem., II, 1908.	On mango . .	Pusa, Bihar.

MARGARODINÆ.

Margarodes, Guilding.

M. formicarum, Guild., p. 115, Trans., Linn., Soc., 1828. *M. formicarum*, Atkinson, J. A. S. B., LV, 1886.	...	South India.
M. indica, Green, p. 73, Rec. Ind. Mus, VII, 1912.	...	Bangalore ; Bombay
M. niger, Green, p. 75, Rec. Ind. Mus, VII, 1912. *M. niger*, Ramakrishna Ayyar, p. 47, Pusa Bull., 87 (1919).	Under soil near grass roots.	Mysore ; Bellary ; Coimbatore.
M. papillosa, Green, p. 74, Rec. Ind. Mus., VII, 1912.	Under soil near grass roots.	Bellary and Bangalore.

ORTHEZIANÆ.

Orthezia, Bosc.

O. insignis, Dougl., Green. Circ., I, (10) Roy. Bot. Gardens, 18 9.		
O. insignis, Dougl. Green., page 6, I. M. N. IV, 1896.	On numerous shrubs	Kandy (Ceylon).
O. insignis, Dougl., Ramakrishna Ayyar, p. 50, Pusa Bull., 87 (1919).	On *Lantana*, etc. .	Nilgiris, Wynaad, Noted only once or twice.

* *Icerya purchasi*, recorded from Ceylon, is omitted from this List.—*Editor*.

CONCHASPINÆ.

Conchaspis, Ckll.

C. socialis, Green, p. 20, C. of C., pt. I. 1896	...	Ceylon.

TACHARDIANÆ.

Tachardia, Blanchard.

T. lacca, Kerr., p. 374, Philos., Trans. LXXI, 1782.	On *Dalbergia, Pongamia*, Rain tree (*Pithecolobium saman*), etc.	In South India.
T. lacca, Kerr., Imms. and Chatterjee, Ind. Forest Mem., 1915.		...
T. lacca, Ramakrishna Ayyar, p. 46, Pusa Bull., 87 (1919).		...
T. lobata, Green (Nom nud ?) Ramakrishna Ayyar, p. 47, Pusa Bull., 87 (1919).	On *Thespesia* . .	Madanapalle, South India.
T. (*Carteria*) *decorella*, Maskell., p. 58, I. M. N., IV, (2) 1896.	On tea . . .	Northern India.
T. decorella var *theæ*, Green, p. 348, Pusa Mem., I, 1907.	Do. . . .	Darjiling.
T. fici, Green, p. 97, I. M. N., V, (3) 1903 .	On *Ficus religiosa* .	Monghyr (Bihar).
T. albizziæ, Green, p. 32, Jour. Ec. Biol., VI, 1911 and p. 27, Pusa Mem., II, 1908.	On *Landolphia, Albizzia*, Croton, etc.	Peradeniya (Ceylon), Darjiling.

ASTEROLECANIINÆ.

Asterolecanium, Targ.

A. bambusæ, Boisd., Green, p. 328, C. of C., pt. IV, 1909, Pl. CXXV.	On Bamboo . .	Ceylon.
A. bambusæ bambusulæ, Ckll., p. 590, Amer, Natur., XXXI, 1897.	Do. . .	India ?
A. exiguum, Green, p. 315, C. of C., pt. IV, 1909, Pl. LXVII.	Do. . .	Yatiyantota (Ceylon).
A. rubrocomatum, Green, p. 316, C. of C., Pt. IV, 1909, Pl. CXIX.	Do. . .	Do.
A. tenuissimum, Green, p. 318, C. of C., Pt. IV, 1909, Pl. CXX.	Do. . .	Do.
A. udagamæ, Green, p. 319, C. of C. Pt. IV, Pt. IV, 1909, Pl. CXX.	Do. . .	Udagama (Ceylon).
A. aureum, Boisd., Green, p. 320, C. of C., Pt. IV, 1909, Pl. CXVIII.	On Orchid . .	Peradeniya (Ceylon).
A. flavociliatum, Green, p. 321, C. of C., Pt. IV, 1909, Pl. CXXXI.	On *Arundinaria* .	Pundaluoya (Ceylon).
A. pudibundum, Green, p. 323, C. of C.	Do.	Do.

A. ceriferum, Green, p. 324, C. of C., Pt. IV, 1909, Pl. CXXIII.	On Bamboo .	. Bogawantalawa (Ceylon).
A. ceriferum var *prominens*, Green, p. 326, C. of C., Pt. IV, 1909, Pl. CXXIII, fig. 5.	Do. .	. Nuwara Eliya (Ceylon).
A. coronatum, Green, p. 327, C. of C., Pt. IV, 1909, Pl. CXXIV.	Do. .	. Peradeniya.
A. tumidum, Green, p. 330, C. of C., Pt. IV, 1909, Pl. CXXI.	Do. .	. Udagama (Ceylon).
A. thespesiæ, Green, p. 331, C. of C., Pt. IV, 1909, Pl. CXXII.	On *Thespesia* .	. Jaffna (Ceylon).
A. delicatum, Green, p. 332, C. of C., Pt. IV, 1909, Pl. CXXVI.	On Bamboo .	. Pundaluoya (Ceylon).
A. delicatum; Green, p. 5, I. M. N., IV, 1896.		
A. solenophoroides, Green, p. 334, C. of C., Pt. IV, 1909, Pl. CXXVII.	On *Arundinaria*	. Pundaluoya (Ceylon).
A. solenophoroides, Green, p. 216, I. M. N., IV, (4) 1896.	On Bamboo .	. Bengal.
A. lanceolatum, Green, C. of C., IV, (Preface 1909).	..	..
A. lineare, Green, p. 336, C. of C., pt. IV, 1909, Pl. CXXVIII:	On *Arundinaria*	. Pundaluoya (Ceylon).
A. milearis var *longa*, Green, (Part) p. 5, I. M. N., IV, 1896.	Do.	. Do.
A. miliaris var *longa*, Green, Ramakrishna Ayyar, p. 46, Pusa Bull., 87 (1919.)	On Bamboo .	. Coimbatore.
A. miliaris Boisd., Green, p. 338, C. of C., Pt. IV, 1909, Pl. CXXIX.	Do. .	. Peradeniya (Ceylon).
A. miliaris var *robusta*, Green, p. 121, Pusa Mem., II, 1908.	Do. .	. Pusa
A. grande, Newstead, p. 182, Ent. M. M., XXX, 1894.	On a grass-like plant	Baluchistan.
A. grande Newstead Green, p. 19, Pusa Mem., II, 1908.	Do.	. Do.

Cerococcus, Comstock.

C. hibisci, Green, p. 19, Pusa Mem., II, 1908.	On branches of *Hibiscus*.	Bombay ; Pusa.
C. hibisci, Green, Ramakrishna Ayyar, p. 45, Pusa Bull., 87 (1919).	On Cotton, *Hibiscus rosa-sinensis*.	Coimbatore, Godavari and Madura.
C. ornatus, Green, p. 306, C. of C., pt. IV, 1909, Pl. CXV.	On bark of coffee plant and on *Carissa*.	Pundaluoya (Ceylon).
C. albospicatus, Green, p. 308, C. of C., Pt. IV, 1909, Pl. CXVI.	On *Symplocos obtusa*	Nuwara Eliya (Ceylon).
C. roseus, Green, p. 310, C. of C., Pt. IV, 1909, Pl. CXVII.	On unknown trees .	Trincomali (Ceylon).

C. ficoides, Green, p. 225, Ent. M. M., XXXV, 1899.	On tea . . .	Assam.
C. ficoides, Green, p. 102, I. M. N., V(3), 1903.	Do. . . .	Do.
C. indicus, Green, p. 5, Jour. Ec. Biol., V, 1910.	On *Helecteres isora* .	Saharanpur (U. P.)
C. bryoides, Maskell, p. 84, New Zel. Tr., XXVI, 1893.	On *Hibiscus rosa-sinensis*.	Madras.
C. bryoides, Maskell, Ramakrishna Ayyar, p. 46, Pusa Bull., 87 (1919).		

Eriococcus, Targ.

E. araucariæ, Mask., Green, p. 7, I. M. N., IV, 1896.	On *Araucaria* .	Nuwara Eliya (Ceylon).
E. araucariæ, Mask., Green, Ramakrishna Ayyar, p. 46, Pusa Bull., 87, (1919)	On a Conif r . .	Bangalore (South India).
E. lagerstrœmiæ, Kuw., Ramakrishna Ayyar, p. 46, Pusa Bull., 87, (1919)	On *Dalbergia* . .	Courtallum (South India).
E. paradoxus, Mask. var *indica*, Green, I. M. N., IV, 1899.	On *Helectres isora* .	Saharanpur (Northern India).

Anomalococcus, Green.

A. cremastogastri, Green, p. 261, Ent. M. M., XXXVIII, 1902.	On *Ficus*, *Feronia*, etc.	Peradeniya (Ceylon).
A. cremastagastri, Green, p. 303, C. of C., Pt. IV, 1909, Pl. CXI.		
A. indicus, Green, (MS) Ramakrishna Ayyar, p. 45, Pusa Bull., 87, 1919.	On *Acacia arabica* . On *Acacia leucophloca*	Coimbatore (South India), Bangalore.

Lefroyia, Green.

L. castaneæ, Green, p. 21, Pusa Mem., II, 1908.	On *Castanea* sp. .	Shillong (Assam).

Pollinia, Targ.

P. ceylonica, Green, p. 341, C. of C., pt. IV, 1909, Pl. CXXX.	On unknown plant .	Ramboda (Ceylon).

Amorphococcus, Green.

A. mesuæ, Green, p. 261, Ent. M. M., XXXVIII, 1902.	On *Mesua ferrea* .	Peradeniya (Ceylon).
A. mesuæ, Green, p. 343, C. of C., pt. IV, 1909, Pl. CXXXI.		

Lecaniodiaspis, Targ.

L. azadirachtæ, Green, p. 298, C. of C., Pt. IV, 1909, Pl. CXII.	On Margosa . .	Jaffna (Ceylon).
L. malaboda, Green, p. 300, C. of C., Pt. IV, 1909, Pl. CXIII.	On *Myristica* .	Pundaluoya (Ceylon).

Kermes, Boit.

K. himalayensis, Green, p. 1, Ent. M. M. XX, 1909, (fig.).	On *Quercus incana*.	Northern India.

DACTYLOPIINÆ.

Dactylopius, Costa.

D. (*Coccus*) *indicus*, Green, p. 28, Pusa Mem., II, 1908.	On *Opuntia dillenii*	Kangra Valley (Northern India).
D. indicus, Green, Ramakrishna Ayyar, p. 39, Pusa Bull., 87, 1919.	On *Opuntia* . .	Godavari district (South India).

Pseudococcus, Westw.

P. citri, Risso, Green, p. 22, Pusa Mem., II, 1908.	On Coffee . .	Mysore.
P. citri, Risso, Ramakrishna Ayyar, p. 37, Pusa Bull., 87, 1919.	On *Erythrina*, Cacao pods.	Nilgiris, etc.
P. longispinus, Targ-Newstead, p. 255, Mon. Br. Cocc., II, 1903.	On Jasmine and Croton.	Ceylon; Calcutta.
Dactylopius longifilis, Barlw., etc., I. M. N., IV, pp. 7 and 75, 1896 and 1897.	On Cedar . .	Mysore.
P. longispinus, Ramakrishna Ayyar, p. 40, Pusa Bull., 87, 1919.	On coconut . .	South Malabar.
P. virgatus, Call., p. 178, Ent., XXVI, 1893. *Dactylopius*, Green, p. 7, I. M. N., IV, 1896. *D. ceriferus*, Newstead, p. 24, I. M. N., III, 1895. *P. virgatus*, Ramakrishna Ayyar, p. 40, Pusa Bull., 87, 1919.	On croton, tomato, cotton, etc.	India and Ceylon.
P. (*Dactylopius*) Ckll. p. 266, Proc. Ac. Nat. Sc. Phil., 1899.		
Dactylopius sacchari, Green, p. 102, I. M. N., V, (3), 1903.	On sugarcane .	Poona.
P. (*Dactylopius*) *sacchari*, Ramakrishna Ayyar, p. 41, Pusa Bull., 87, 1919.	On paddy . .	Tanjore, Trichinopoly, etc., in South India.
P. (*Dactylopius*) *saccharifolii*, Green, p. 23, Pusa Mem., II, 1908.	On sugarcane .	Bengal.
P. (*Dactylopius*) *viridis*, Newst., p. 25, I. M. N., III, (5), 1894.	On *Hygrophilia* and Rain tree.	Madras.
P. (*Dactylopius*) *cocotis*, Mask., p. 66, I. M. N., III, (1), 1893.	On coconut . .	Laccadives.
P. (*Dactylopius*) *cocotis*, Ramakrishna Ayyar, p. 42, Pusa Bull., 87, 1919.	Do. . .	Malabar.
P. (*Dactylopius*) *nipæ*, Mask., Green, p. 23, Pusa Mem., II, 1908.	On cotton and potato tubers.	Bengal.
P. (*Dactylopius*) *nipæ* V. S. Ayyar, p. 8, Imp. For. Bull., 11, 19	On *Casuarina* .	Coromandel Coast, Madras.

P. (*D.*) *bromeliæ* Bouche Cotes, p. 51, I. M. N., III (5), 1894.	On mulberry . . On Pine-apple .	Berhampore (Bengal). N. Malabar, (T. V. R.).
P. (*D.*) *scrobicularum*, Green, p. 8, I. M. N., IV, (1), 1896.	On *Elæocarpus* leaves.	Pundaluoya (Ceylon.)
P. (*D.*) *formiceticola*, Newst., p. 86, Ent. M. M., XXXVII, 1901.	In *Cremastogaster* nests.	Konkan (Western India).
P. (*D.*) *theæcola*, Green, p. 347, Pusa Mem., I, 1907.	On tea . . .	Assam.
P. corymbatus, Green, (MS.) Ramakrishna Ayyar, p. 41, Pusa Bull., 87, 1919.	On cotton, jak and *Citrus*.	In different parts of South India.
P. crotonis,* Green, p. 35, Jour. Ec. Biol., VI, 1911.	On rubber (Castilloa)	Ceylon.
P. crotonis, Ramakrishna Ayyar, p. 41, Pusa Bull., 87, 1919.	On *Adenophyllum* and *Ficus*.	Coimbatore and the Northern Circars.

Naiacoccus, Green.

N. serpentinus, Green, p. 117, Rec. Ind. Mus., XVIII, 1919.	On *Tamarix articulata*.	Lahore.
N. serpentinus var *minor*, Green, p. 118, Rec. Inn. Mus. XVIII. 1919.	On *Tamarix stricta* .	Baluchistan.

Phenacoccus, Ckll.

P. (*Pseudococcus*) *mangiferæ*, Green, p. 7, I. M. N., IV, (1), 1896.	On mango . .	Pundaluoya (Ceylon).
P. (*Pseudococcus mangiferæ*, Green, Ramakrishna Ayyar, p. 43, Pusa Bull., 87, 1919.	On mango, *Echitis* leaves.	Coimbatore ; Vizagapatam district.
P. hirsutus, Green, p. 25, Pusa Mem., II, 1908.	On unknown tree without locality. On Mulberry . . I have recently noted this species on *Ficus* leaves in Kollegal.	 Northern India.
P. iceryoides, Green, p. 26, Pusa Mem., II, 1908.	On mango . .	Calcutta and Northern Circars, Madras.
P. iceryoides, Ramakrishna Ayyar, p. 43, Pusa Bull., 87, 1919.	On *Odina wodier* . On *Citrus* . . On *Capparis* . . On *Boswellia* . . On Rain-tree, cotton, etc.	Coimbatore. N. Circars, Madras. Surat (Bombay). Tanjore (Madras).
P. insolitus, Green, p. 26, Pusa Mem., II, 1908.	On *Sida cordifolia* .	Pusa.
P. insolitus, Ramakrishna Ayyar, p. 42, Pusa Bull., 87, 1919.	On Brinjal plant (*Solanum*).	All over South India.
P. ballardi, Newst., p. 17, Bull. Ent. Res., VIII, 1917. *P. ballardi*, Ramakrishna Ayyar, p. 43, Pusa Bull., 87, 1919.	On Mango . .	Coimbatore (South India)

* The correct name appears to be *lilacinus*, Ckll. (see p. 18, *ante*)—*Editor.*

P. ornatus, Green (MS.) Ramakrishna Ayyar, p. 44, Pusa Bull., 87, 1919.	On wild jasmine creeper.	Courtallum (South India) and Ceylon (Green).
P. quarternus, Green (MS.) V, Subramania Ayyar, p. 8, Impl. Forest Bull., 11, 1912.	On *Casuarina* stem	Coromandel Coats (Madras).

Ripersia, Sign.

R. sacchari, Green, p. 37, I. M. N., V(2) 1900.	On sugarcane .	Gorakhpur (U. P.).
R. sacchari, Green, Ramakrishna Ayyar, p. 44, Pusa Bull., 87, 1919.	Do. .	Coimbatoro (South India).
R. theæ, Rutherford, p. 111, B. J., XXIV, 1915.	On tea . . .	Peradeniya (Ceylon)
R. resinophila, Green, p. 395, Bull. Ent. Res., VI, 1916.	On *Pinus longifolia*	Himalayas.

Antonina, Sign.

A. indica, Green, p. 27, Pusa Mem., II, 1908.	At base of grass . .	Bengal.

[I have recently noted this under roots of grasses in Coimbatore (South India).]

A. maritima, Green, Ramakrishna Ayyar, p. 45, Pusa Bull., 87, 1919.	On roots of grass .	Coimbatore (South India).
A. zonata, Green, p. 175, Ent. M. M., V, 1919.	On Bamboo (*Temostychum attenuatum*).	Pundaluoya (Ceylon).

Kermicus, Newstead.

K. wroughtoni, Newst., p. 170, Ent. M. M., XXXIII, 1897.		India.

LECANIINÆ.

Aclerda, Sign.

A. japonica, Newst., p. 84, Ent. M. M., XXXVII, 1901. *A. japonica*, Green, p. 95, I. M. N., V(3), 1903.	On Sugarcane .	Northern India.
A. distorta, Green, p. 290, C. of C., Pt. IV, 1909, Pl. CXI.	On *Arundinaria* .	Pundaluoya (Ceylon).

Ceronema, Mask.

C. kœbeli, Green, p. 256, C. of C., Pt. IV, 1909, Pl. CXVI.	On *Sapium sebiferum*	Kandy (Ceylon).
C. kœbeli, Rutherford, p. 267, Bull. Ent. Res., V, 1914.	On *Pithecolobium* .	Peradeniya (Ceylon).
C. japonica, Mask., p. 243, Ent. M. M., XXXIII, 1897, and p. 11, I. M. N., V(1) (Green).	On tea. . .	Bengal.

Eriochiton, Mask.

E. theæ, Green, p. 10, I. M. N., V(1), 1900	On Tea . . .	Darjiling.

Ceroplastes, Gray.

C. ceriferus Anderson-Green, p. 270, C. of C., Pt. IV, 1909, Pl. CIV.	On *Lawsonia* (Coimbatore) other trees in different parts of India; on mulberry, *Ficus*, etc., in Ceylon.	
C. ceriferus Ramakrishna Ayyar, p. 29, Pusa Bull, 87, 1919.	On coconut (Malabar, Coimbatore) *Ficus*.	
C. actiniformis, Green, p. 275, C. of C., Pt. IV, 1909, Pl. CIV.	*Calophyllum*. Canna, etc., in different parts of South India; also noted on coconut, etc., in Ceylon.	
C actiniformis, Green, Ramakrishna Ayyar, p. 29, Pusa Bull., 87, 1919.		
C. rubens, Mask., Green, p. 273, C. of C., Pt. IV, 1909, Pl. CIII.	On tea, pear, mango, etc.	Ceylon.
C. rubens, Mask., Ramakrishna Ayyar, p. 30, Pusa Bull., 87, 1919.	On jak, mango, palms, *Calophyllum*.	In South India, also noted in Assam.
C. floridensis, Comst., Green, p. 227, C. of C., Pt. IV, 1909, Pl. CV.	On tea, guava, etc. .	All over Ceylon.
C. floridensis, Comst., Ramakrishna Ayyar, p. 30, Pusa, Bull., 87, 1919.	On *Anacardium*, *Michelia*, etc.	South India.

Ceroplastodes, Ckll.

C. cajani, Mask., Green, p. 285, C. of C., Pt. IV, 1909, Pl. CVIII.	On *Abrus*, *Atylosia*, etc.	In Ceylon.
C. cajani, Mask., Green, Pusa Mem., II, 1908.	On *Ocimum* (Calcutta	*Coleus* (Surat).
C. cajani, Mask., Ramakrishna Ayyar, p. 32, Pusa Bull., 87, 1919.	On *Zizyphus*, *lab-lab* and *Ocimum* (Coimbatore), on red gram all over South India.	...
C. chiton, Green, p. 287, C. of C., Pt. IV, 1909, Pl. CIX.	On *Cassia* . .	Mahailluppalama (Ceylon).
C. virescens, Green, p. 288, C. of C., Pt. IV, 1909, Pl. CXX.	On Cacao . .	Matale (Ceylon).

Inglisia, Mask.

I. chelonioides, Green, p. 283, C. of C., Pt. IV, 1909, Pl. CVII.	On *Gelonium lanceolatum*.	Pundaluoya (Ceylon).
I. chelonioides, Green, p. 283, C. of C., Ayyar, p. 31, Pusa Bull., 87, 1919.	On *Parkinsonia aculeata*.	Coimbatore (South India).
I. bivalvata, Green, p. 95, I. M. N., V(3), 1903.	On *Thespesia populnea*.	Rameswaram (South India).
I. bivalvata, Green, Ramakrishna Ayyar, p. 31, Pusa Bull., 87, 1919.	On red gram (*Cajanus*).	Godavari district (South India).
I. castilloæ, Green, p. 29, Jour. Ec. Biol., VI, 1911.	On *Castilloa* . .	Koslanda (Ceylon).

Pseudopulvinaria, Atk.

P. sikkimensis, Atk., p. 58, J. A. S. B., LVIII, Pt. II, 1889.	On Cinchona .	. Sikkim.

Protopulvinaria, Ckll.

P. longivalvata, Green, p. 254, C. of C., Pt. IV, 1909, Pl. XCV.	On *Piper nigrum* .	Heneratgoda (Ceylon).

Neolecanium, Parrot.

N. crustuliforme, Green, p. 252, C. of C., Pt. IV, 1909.	On unknown tree .	Chilaw (Ceylon).
N. cinnamomi, Rutherford, p. 265, Bull. Ent.	On ? ? . . .	Ceylon
N. pseudoleœ, Rutherford, p. 112, B. J., XXIV, 1915.	On Cinnamon .	Peradeniya (Ceylon).

Vinsonia, Sign.

V. stellifera, Westw., Green, p. 280, C. of C., Pt. IV, 1909, Pl. CVI.	On mango, coconut, *Garcinia*, etc.	Ceylon.
V. stellifera, Westw., Ramakrishna Ayyar, p. 30, Pusa Bull., 87, 1919.	On coconut, rose-apple, nutmegs, etc.	In South India.

Pulvinaria, Targ.

P. psidii, Mask., Green, p. 264, C. of C., Pt. IV, 1909, Pl. C.	On guava, citrus, Morinda, mango, etc.	All over South India and Ceylon.
P. psidii, Mask., Ramakrishna Ayyar, p. 27, Pusa Bull., 87, 1919.	...	...
P. thespesiœ, Green, p. 259, C. of C., Pt. IV, 1909, Pl. XCVII.	On *Thespesia* .	Jaffna (Ceylon).
P. thespesiœ, Ramakrishna Ayyar, p. 28, Pusa Bull., 87, 1919.	Do. . .	Godavari and Tanjore (South India).
P. tessellata, Green, p. 260, C. of C., Pt. IV, 1909, Pl. XCVIII.	On *Ophiorrhyza* and *Strobilanthus*.	Pundaluoya and Nuwara Eliya (Ceylon).
P. cellulosa, Green, p. 262, C. of C., Pt. IV, 1909, Pl. XCIX.	On *Citrus* . .	Pundaluoya (Ceylon).
P. ixorœ, Green, p. 266, C. of C., Pt. IV, 1909, Pl. CI.	On *Ixora coccinea* .	Batticaloa (Ceylon).
P. tomentosa, Green, p. 267, C. of C., Pt. IV, 1909, Pl. CI.	On ? ? . .	Pundaluoya (Ceylon).
P. floccifera, Westw., Green, p. 7, I. M. N., V(1), 1900.	On *Acalypha* leaves	Calcutta.
P. maxima, Green, Ramakrishna Ayyar, p. 28, Pusa Bull., 87, 1919.	On *Melia* and Cotton.	Coimbatore (South India).
	On *Jatropha curcas* .	Kistna district (South India.)

P. burkilli, Green, p. 31, Pusa Mem., II, 1908.	On Croton . .	Calcutta.
P. obscura, Newstead, p. 23, I. M. N., III(5), 1894.	On *Hygrophila spinosa.*	Madras.

Lecanium, Burm.

L. nigrum, Niet., Green, p. 229, C. of C., Pt. I, 1904, Pl. LXXXIV. *L. nigrum*, Niet, Ramakrishna Ayyar, p. 32, Pusa Bull., 87, 1919.	On numerous plants specially coffee, sandalwood, Portia tree, cotton.	All over India and Ceylon.
L. hemisphæricum, Targ, Green, p. 232, C. of C., Pt. III, 1904, Pl. LXXXV. *L. hemisphæricum*, Targ, Green, Ramakrishna Ayyar, p. 32, Pusa Bull., 87, 1919.	On coffee and many other plants.	South India and Ceylon.
L. hemisphæricum var *filicum*, Bdv., Ramakrishna Ayyar, p. 33, Pusa Bull., 87, 1919.	On ferns . .	Salem; Ganjam (South India).
L. hesperidum, L. Green, p. 188, C. of C., Pt. III, 1904, Pl. LXIII. *L. hesperidum* L. Green, Ramakrishna Ayyar, p. 33, Pusa Bull., 87, 1919.	On tea, citrus, etc. . On *Dalbergia* . . On Coconut . . On *Citrus* . .	Ceylon. Bengal. Malabar. Godavari.
L. oleæ, Bern, Green, p. 227, C. of C., Pt. III, 1904, Pl. LXXXIII. *L. oleæ*, Bern, Ramakrishna Ayyar, p. 33, Pusa Bull., 87, 1919.	On *Grewia, Duranta, Thespesia* and *Cajanus indicus.* On *Erythrina*, tamarind, *Sesbania, Thespesia* and *Hygrophila.*	Ceylon. South India.
L. longulum, Doug., Green, p. 221, C. of C., Pt. III, 1904, Pl. LXXX.	On *Albizzia, Acacia, Grevillea, Loranthus*, etc.	Ceylon.
L. longulum, Doug., Ramakrishna Ayyar, p. 34, Pusa Bull., 87, 1919.	On *Vitis* . . On *Cajanus indicus*	Assam. Godavari (South India).
L. expansum, Green, p. 235, C. of C., Pt. III, 1904, Pl. LXXXVI.	On *Dalbergia* and *Litsea.*	Pundaluoya (Ceylon).
L. expansum, Green, Ramakrishna Ayyar, p. 34, Pusa Bull., 87, 1919.	On *Calophyllum* and *Ficus retusa.*	Madras, Mysore.
L. expansum var *quadratum*, Green, p. 236, C. of C., Pt. III, 1904, Pl. LXXXVI.	On nutmeg . .	Balangoda, Ceylon.
L. formicarii, Green, p. 190, C. of C., Pt. III, 1904, Pl. LXIV.	On tea, cinchona, etc.	Ceylon.
L. formicarii, Green, Pusa Mem., II, 1908, p. 29.	On unknown plant .	Mysore.
L. ramakrishnæ, Green, (MS.) Ramakrishna Ayyar, p. 35, Pusa Bull., 87, 1919.	On *Ficus bengalensis*	Godavari (South India).
L. signiferum, Green, p. 197, C. of C., Pt. III, 1904, Pl. LXVIII.	On *Begonia* sp., *Caryota.*	Ceylon.

L. signiferum, Ramakrishna Ayyar, p. 35, Pusa Bull., 87, 1919.	On banana leaves. .	Vizagapatam District.
L. adersi, Newstead, p. 357, Bull. Ent. Res., VII, 1917.	On Mango . .	Coimbatore (South India).
L. adersi, Ramakrishna Ayyar, p. 35, Pusa Bull., 87, 1919.	...	...
L. tessellatum, Green, p. 206, C. of C., Pt. VII, 1904, Pl. LXI.	On *Calophyllum* .	Do.
L. tessellatum, Sign., Ramakrishna Ayyar, p. 36, Pusa Bull., 87, 1919.		
L. tessellatum var *perforatum*, Newst., Green, p. 207, C. of C., Pt. III, 1904, Pl. LXXII.	On *Caryota*, Cinnamon, Coconut, etc.	Ceylon.
L. mercaræ, Green (MS.) Ramakrishna Ayyar, p. 36, Pusa Bull., 87, 1919.	On Coffee.	Coorg (South India).
L. gymnospori, Green, p. 29, Pusa Mem., II, 1908.	On *Gymnosporia* .	Narasaraopet (South India).
L. gymnospori, Green, Ramakrishna Ayyar, p. 36, Pusa Bull., 87, 1919.	...	...
L. marsupiale, Green, p. 212, C. of C., Pt. III, 1904, Pl. 1304, Pl. LXXV.	On black pepper, *Pothos* and *Anona* sp.	Ceylon.
L. marsupiale, Ramakrishna Ayyar, p. 36, Pusa Bull., 87, 1919.	On black pepper .	Malabar and Anamalais (South India).
L. depressum, Targ, Ramakrishna Ayyar, p. 36, Pusa Bull., 87, 1919.	On *Eranthymum*, *Thespesia* and banana.	Coimbatore (South India).
(Maskell considers this the same as *L. nigrum*, N.).		
L. acutissimum, Green, p. 218, C. of C., Pt. III, 1904, Pl. LXXVIII.	On coconut, *areca*, pepper, etc.	Ceylon.
L. acutissimum, Ramakrishna Ayyar, p. 37, Pusa Bull., 87, 1919.	On coconut and mango.	Coimbatore (South India).
L. viride, Green, p. 199, C. of C., Pt. III, 1904, Pl. LXIX.	On coffee, *citrus*, cinchona, etc.	Ceylon.
L. viride, Ramakrishna Ayyar, p. 37, Pusa Bull., 87, 1919.	On coffee, *citrus*, *Aegle*, *Carissa*, Guava, etc.	South India.
L. ophiorrhizæ, Green. p. 193, C. of C., Pt. III, 1904, Pl. LXVI.	On *Ophiorrhiza* .	Pundaluoya, (Ceylon).
L. ophiorrhizæ, Ramakrishna Ayyar, p. 37, Pusa Bull., 87, 1919.	On *Diospyros chloroxylon*.	Kurnul (South India).
L. discrepans, Green, p. 204, C. of C., Pt. III, 1904, Pl. LXX.	On Tea . . .	Pundaluoya (Ceylon).
L. discrepans, Ramakrishna Ayyar, p. 38, Pusa Bull., 87, 1919.	On mango and banana,	Godavari District.
L. capparidis, Green, p. 187, C. of C., Pt. III, 1904, Pl. LXIII.	On *Capparis moonii*	Pundaluoya, Ceylon.
L. frontale, Green, p. 192, C. of C., Pt. III, 1904, Pl. LXV.	On *Calophyllum* .	Do.

L. acuminatum, Sign., Green, p. 195, C. of C., Pt. III, 1904, Pl. LXVII.	On *Jasminum* leaves	Pundaluoya, Ceylon.
L. punctuliferum, Green, p. 205, C. of C., Pt. III, 1904, Pl. LXX.	On *Michelia champaka* and mango.	Peradeniya (Ceylon).
L. subtessellatum, Green, p. 206, C. of C., Pt. III, 1904, Pl. LXXI.	On ? ? . .	Kandy (Ceylon).
L. antidesmæ, Green, p. 209, C. of C., Pt. II, 1904, Pl. LXXIII.	On *Antidesma* .	Pundaluoya, Ceylon.
L. piperis, Green, p. 210, C. of C., Pt. III, 1904, Pl. LXXIV.	On *Piper* sp. an *Psychotria*.	Do.
L. bicruciatum, Green, p. 214, C. of C., Pt. III, 1904, Pl. LXXVI.	On *Eugenia*, *Callophyllum*, etc.	Peradeniya, Ceylon.
L. mangiferæ, Green (1889) Green, p. 216, C. of C., Pt. III, 1904, Pl. LXXVII.	On mango and *Litsea*.	Do.
L. arundinariæ, Green, p. 220, C. of C., Pt. III, 1904, Pl. LXXIX.	On *Arundinaria* sp.	Do.
L. caudatum, Green (1896) Green, p. 223, C. of C., Pt. III, 1904, Pl. LXXXI.	On coffee, *Loranthus*,	Kandy, Ceylon.
L. psidii, Green, p. 225, C. of C., Pt. III, 1904, Pl. LXXXII.	On guava, jak, etc. .	Peradeniya, Ceylon.
L. marginatum, Green (1896) Green, p. 237, C. of C., Pt. III, 1904, Pl. LXXXVII.	On *Psychotria thwaitesii*.	Pundaluoya, Ceylon.
L. geometricum, Green (1896) Green, p. 239, Pt. III, 1904, C. of C., Pl. LXXXVIII.	On *Glycosmis pentaphylla*.	Do.
L. calophylli, Green, p. 240, C. of C., Pt. III, 1904, Pl. LXXXIX.	On *Calophyllum* .	Nuwara Eliya, Ceylon.
L. peradeniyense, Green, p. 341, C. of C., Pt. III, 1904, Pl. XC.	On *Piper nigrum* .	Peradeniya, Ceylon.
L. planum, Green, p. 243, C. of C., Pt. III, 1904, Pl. XCI.	On *Nothopegia* .	Pundaluoya, Ceylon.
L. zonatum, Green, p. 245, C. of C., Pt. III, 1904, Pl. XCII.	On *Garcinia* .	Peradeniya, Ceylon.
L. maritimum, Green (1896) Green, p. 246, C. of C., Pt. III, 1904, Pl. XCII.	On *Carissa* ? and *Ixora* on seashore.	Colombo, Ceylon.
L. watti, Green, p. 6, I. M. N., V(1), 1900.	On tea . . .	Assam.
L. capreæ, Linn., Green, p. 29, Pusa Mem., II, 1908.	On almond . .	Baluchistan.
L. (*Akermes*) *montanum*, Green, p. 30, Pusa Mem., II, 1908.	On unknown tree. .	Janusai (Himalayas 7,000 feet).
L. (*Coccus*) *litzeæ*, Rutherford, p. 111, B. J., XXIV, 1915.	On *Litsea* . .	Peradeniya, Ceylon.
L. persicæ, Fab. Green, p. 31, Pusa Mem., II, 1908.	On mulberry . .	Jhelum (Punjab).

Hemilecanium, Newst.

Lecanium imbricans, Green, p. 94, I. M. N., V(3), 1903.	On *Ficus* and Cedar	Mysore.
Hemilecanium imbricans, Ramakrishna Ayyar, p. 38, Pusa Bull., 87, 1919.	On *Jatropa multifida* and *Ailanthus excelsa*.	Coimbatore, South India.

DIASPINÆ.

Chionaspis, Sign.

Ch. vitis, Green (1896) Green, p. 140, C. of C., Pt. II, 1899, Pl. XLVII.	On *Vitis lanceolaria* mango	Ceylon. Pusa, Bihar.
Ch. vitis, *Green*, Ramakrishna Ayyar, p. 9, Pusa Bull., 87, 1919.	On mango . .	Coimbatore and Nilgiris.
Ch. dilatata, Green, p. 148, C. of C., Pt. II, 1899, Pl. LI.	On nut-meg, mango *Eurycles*, etc.	Ceylon.
Ch. dilatata, Green, Ramakrishna Ayyar, p. 19, Pusa Bull., 87, 1919.	On Palm and on areca palm.	Calcutta. Bangalore, South India.
Ch. varicosa, Green, p. 146, C. of C., Pt. II, 1899, Pl. L.	On *Gelonium lanceolatum*.	Pundaluoya, Ceylon.
Ch. varicosa, Green, Ramakrishna Ayyar, p. 10, Pusa Bull., 87, 1919.	On pepper and on *Loranthus*.	Coorg. Nilgiris.
Ch. varicosa, Green, p. 437, Rec. Ind. Mus., XVI, 1919.	...	...
Ch. spiculata, Green, p. 437, Rec. Ind., Mus., XVI., 1919 (Fig.).	On bamboo leaf .	Periaghat (Malabar).
Ch. spiculata, Green, Ramakrishna Ayyar, p. 11, Pusa Bull., 87, 1919.	...	...
Ch. acuminata, Green, p. 136, C. of C., Pt. II, 1899, Pl. XLV.	On *Ardesia* sp. .	Pundaluoya, Ceylon.
Ch. *acuminata*, Green, Ramakrishna Ayyar, p. 11, Pusa Bull., 87, 1919.	On *Evodia* and Bossia.	Malabar. Madura.
Ch. acuminata var *atricolor*, Green, Ramakrishna Ayar, p. 11, Pusa Bull., 87, 1919.	On *Carissa* and tamarind.	Coimbatore, South India.
Ch. mussændæ, Green, p. 117, C. of C., Pt. II, 1899, Pl. XXXV.	On *Mussænda* and *Loranthus*.	Pundaluoya, Ceylon.
Ch. rhododendri, Green, p. 119, C. of C., Pt. II, 1899, Pl. XXXVI.	On *Rhododendron* .	Nuwara Eliya, Ceylon.
Ch. scrobicularum, Green, p. 121, C. of C., Pt. II, 1899, Pl. XXXVII.	On *Elæocarpus* .	Pundaluoya, Ceylon.
**Ch. graminis*, Green, p. 123, C. of C., Pt. II, 1899, Pl. XXXVIII.	On *Andropogon Nerdus*.	Ceylon. ..
Ch. elongata, Green, p. 125, C. of C., Pt. II, 1899, Pl. XXXIX.	On Bamboo leaves .	Pundaluoya, Ceylon.
Ch. elongata, Green, p. 438, Rec. Ind., Mus. XVI, 1919.	On Bamboo . .	Ootacamund (Nilgiris).

* See also on page 352.

Ch. arundinariæ, Green, p. 127, C. of C., Pt. II, 1899, Pl. XL.	On *Arundinaria* .	Kelani Valley (Ceylon).
Ch. minuta, Green, p. 128, C. of C., Pt. II, 1899, Pl. XLI.	On *Tetranthera* .	Pundaluoya, Ceylon.
Ch. herbæ, Green, p. 132, C. of C., Pt. II, 1899, Pl. XLIII.	On grasses of sorts .	Do.
(This has recently been collected from the Nilgiris in South India.)		
Ch. polygoni, Green, p. 134, C. of C., Pt. II, 1899, Pl. XLIV.	On *Polygonum* .	Pundaluoya, Ceylon.
Ch. elægni, Green, p. 138, C. of C., Pt. II, Pt. II, 1899, Pl. XLVI.	On *Elæagnus latifolia*.	Do.
Ch. hedyotidis, Green, p. 142, C. of C., Pt. II, 1899, Pl. XLVIII.	On *Hedyotis* . .	Do.
Ch. litzeæ, Green, p. 144, C. of C., Pt. II, 1899, Pl. XLIX.	On *Litsea zeylanica* .	Do. Nuwara Eliya.
Ch. litzeæ, Green, p. 438, Rec. Ind. Mus., XVI, 1919.	On *ghumti* . .	Darjiling.
Ch. megaloba, Green, p. 149, C. of C., Pt. II, 1899, Pl. LII.	On *Psidium* sp ? .	Kandy, Ceylon.
Ch. megaloba, Green, p. 438, Rec. Ind. Mus., XVI.	On *Zizyphus jujuba* .	Pusa.
Ch. flava, Green, p. 150, C. of C., Pt. II, 1899, Pl. LIII.	On *Antidesma* .	Pundaluoya, Ceylon.
Ch. fodiens, Green, p. 155, C. of C., Pt. II, 1899, Pl. LV.	On bark of *Loranthus*.	Pundaluoya, Ceylon.
Ch. galliformans, Green, p. 158, C. of C., Pt. II, 1899, Pl. LVI.	On *Hedyotis* . .	Kalutara, Ceylon.
Ch. decurvata, Green, p. 63, I. M. N., V(3), 1903.	On paddy . .	Calcutta.
**Ch. graminis* var *divergens*, Green, p. 37, Pusa Mem., II, 1908.	On *Andropogon* .	Hoshiarpur, North India.
(I have recently noted it on *Andropogon nardus* in Wynaad, South India.)		
Ch. manni, Green, p. 344, Pusa Mem., I, 1907.	On tea on brinjal on *Ficus*.	Assam, Kangra, Calcutta.
Ch. subcorticalis, Green, p. 351, B. J., XVI, 1905.	On bark of Jak .	Peradeniya, Ceylon.
Ch. strobilanthi, Green, p. 352, B. J., XVI, 1905.	On *Strobilanthus* .	Haputale, Ceylon.
Ch. coronifera, Green, p. 353, B. J., XVI, 1905.	On unknown plant .	Galgamma, Ceylon.
Ch. cinnamomi, Green, p. 354, B. J., XVI, 1905.	On cinnamon .	Pundaluoya, Ceylon.
Ch. annandalei, Green, p. 434, Rec. Ind. Mus., XVI, 1919.	On *Dendrocalamus strictus*.	Parasnath (Bihar).

* See also on page 351.

Ch. caroli, Green, p. 434, Rec., Ind. Mus., XVI, 1919.	On tea . . .	Darjiling.
Ch. chir, Green, p. 435, Rec. Ind. Mus., XVI, 1919.	On *chir* pine . .	Almora (U. P.).
Ch. (Phenacaspis) gudalura, Green, p. 436, Rec. Ind. Mus., XVI, 1919.	On Bamboo . .	Gudalur (Nilgiris).

Howardia, Berl. and Leon.

H. (Chionaspis) biclavis, Comst.-Green, p. 152, C. of C., Pt. II, 1899, Pl. LIV.	On cinchona, tea, etc., in Ceylon ; on tea in Nilgiris.

Hemichionaspis, Ckll.

H. dracænæ, Cooley, Ramakrishna Ayyar, p. 13, Pusa Bull., 87, 1919.	On Areca palm .	South Malabar.
H. aspidistræ Sign, Green, p. 110, C. of C., Pt. II, 1899, Pl. XXXII.	Areca, *Acacia*, *Ficus*, etc.	Ceylon.
H. aspidistræ Sign, Ramakrishna Ayyar, p. 13, Pusa Bull., 87, 1919.	On areca and jak (Mysore), on pepper and rubber (Western Ghats), on *Citrus* (Godavari) and *Ficus* (Coimbatore and Godavari).	
H. separata, Green, p. 5, I. M. N., V(1), 1900.	On tea . . .	Darjiling.
H. minor Mask. (*Chionaspis albizziæ* Green) p. 115, C. of C., Pt. II, 1899, Pl. XXXIV.	On *Albizzia* and *Pithecolobium* (Ceylon), on pumpkin stem (Kistna, S. India).	
H. minor Mask, Ramakrishna Ayyar, p. 14, Pusa Bull., 87, 1919.	On *Agave Cassia* and *Diospyrus* in the Ceded districts (South India), on *Crotalaria* (Calcutta) and on tamarind (Coimbatore).	
H. fici, Green, p. 37, Pusa Mem., II, 1908.	On *Ficus glomerata* .	Pusa (Bihar).
H. minima, Green, p. 38, Pusa Mem., II. 1908.	On *Ficus* sp. . .	Do.
H. alatæ, Rutherford, p. 262, Bull. Ent. Res., 1915.	On *Cassia alata* .	Peradeniya (Ceylon).
H. theæ, Mask, Green, p. 113, C. of C., Pt. II, 1899, Pl. XXXIII.	On Tea, *Psychotria*.	Ceylon.
H. theæ, Mask, Ramakrishna Ayyar, p. 15, Pusa Bull., 87, 1919.	On Pomegranate leaves.	Coimbatore (South India).
H. chionaspiformis, Newst., Ramakrishna Ayyar, p. 15, Pusa Bull., 87, 1919.	On wild indigo	Do.

Dinaspis, Leon.

D. (Chionaspis) permutans, Green, p. 130, C. of C., Pt. II, 1899, Pl. XLII. *D. (Chionaspis) permutans*, Green, Ramakrishna Ayyar, p. 11, Pusa Bull., 87, 1919.	On *Antidesma* . On *Evodia* . .	Pundaluoya, Ceylon Peria Pass, Malabar (South India).

A. rossi, Mask., Ramakrishna Ayyar, p. 18, Pusa Bull., 87, 1919.	On mango (Godavari), on *Carissa* (Coimbatore) and on pomegranate (Bilaspur C. P.)	
A. cyanophylli, Sign., Green, p. 51, C. of C., Pt. I, 1896, Pl. IX.	On toa, cinchona, etc.	Ceylon.
A. cyanophylli, Sign., Ramakrishna Ayyar, p. 18, Pusa Bull., 87, 1919.	On banana and Ceara rubber.	Nilgiris.
A. cydoniæ, Comst., Ramakrishna Ayyar, p. 19, Pusa Bull., 87, 1919.	On imported grape, fig., pear, etc. (South India).	
A. dictyosopermi, Morg., Green, p. 68, B. J., XIII, 1900.	On *Cycas*, *Opuntia* and *Calophyllum*.	Ceylon.
A. dictyosopermi, Morg., Ramakrishna Ayyar, p. 19, Pusa Bull., 87, 1919.	On *Dendrobium* (Bangalore), on *Mimusops elengi* (Coconada, South India).	
A. tamarindi, Green, p. 439, Rec. Ind. Mus., XVI, 1919.	On tamarind leaves	Coimbatore, South India.
A. tamarindi, Ramakrishna Ayyar, p. 20, Pusa Bull., 87, 1919.	...	...
A. (*Hemiberlesea*) *camelliæ*, Sign., Green, p. 60, C. of C., Pt. I, 1896, Pl. XIII.	On tea, cinchona, etc.	Ceylon.
A. (*Hemiberlesea*) *camelliæ*, Sign., Ramakrishna Ayyar, p. 18, Pusa Bull., 87, 1919.	On tea and on English elm.	Nilgiris.
A. (*Hemiberlesea*) *pseudocamelliæ*, Green, p. 438, Rec. Ind. Mus., XVI, 1919.	...	...
A. (*Hemiberlesea*) *pseudocamelliæ*, Ramakrishna Ayyar, p. 20, Pusa Bull., 87, 1919.	On *Capparis stylosa*	Bellary District (South India).
A. moorei, Green, p. 199, Ent. M. M., 1896.	On *Grislea tomentosa*.	Madras.
A. aurantii, Mask, Green, p. 58, C. of C., Pt. I, 1896.	On aloe and *Citrus* trees.	Ceylon.
A. aurantii, Mask, Ramakrishna Ayyar, p. 20, Pusa Bull., 87, 1919.	On rose (North India and South India), on *Citrus* (Pusa, Bihar).	
A. ficus, Ashm., Green, p. 43, C. of C., Pt. I, 1896, Pl. V.	On *Rhododendron* .	Ceylon.
A. ficus, Ashm., Ramakrishna Ayyar, p. 21, Pusa Bull., 87, 1919.	On *Ficus*, mango, *Citrus*, *Eugenia*, etc., in South India, on *Phœnix*, areca, orange, in Bombay.	
A. triglandulosus, Green, p. 33, Pusa Mem., II, 1908.	On unknown plant (Mahableshwar, Bombay) and on jak (Bangalore, South India).	
A. trilobitiformis, Green, p. 41, C. of C., Pt. I, 1896, Pl. IV.		
A. trilobitiformis, Green, p. 66, B. J., XIII, 1900.	On *Dalbergia* and *Ixora* (Ceylon);	Calcutta.
A. trilobitiformis, Ramakrishna Ayyar, p. 21, Pusa Bull., 87, 1919.	on ?	
A. transparens, Green, p. 69, B. J., XIII, 1900.	On *Dalbergia* .	Ceylon.

A. excisus, Green, p. 53, C. of C., Pt. I, 1896, Pl. X.	On *Cyanotis pilosa* .	Pundaluoya, Ceylon.
A. putearus, Green, p. 54, C. of C., Pt. I, 1896, Pl. X.	On *Strobilanthus* .	Do.
A. secretus, Ckll., Green, p. 64, C. of C., Pt. I, 1896, Pl. XV.	On bamboo . .	Do.
A. theæ, Mask, p. 59, I. M. N., II, 1891 .	On tea . . .	Kangra, Punjab.
A. theæ var *rhododendri*, Green, p. 67, B. J., XIII, 1900.	On *Rhododendron* .	Nuwara Eliya (Ceylon).
A. artocarpi, Green, p. 200, Ent. M. M., 1896.	On *Artocarpus* .	Bombay.
A. glomeratus, Green, p. 93, I. M. N., (V. 3), 1903.	On sugarcane .	Northern India
A. hartii, Ckll., Green, p. 439, Rec. Ind. Mus., XVI, 1919.	On *Curcuma* (Poona, Bombay); also noted recently at Coimbatore on turmeric.	
A. longispinus, Morgan, Green, p. 340, B. J., XVI, 1905.	On jak . . .	Ceylon.
A. cuculus, Green, p. 341, B. J., XVI, 1905.	In galls of *Mesua* .	Peradeniya, Ceylon.
A. (*Chrysomphalus*) *pedronis*, Green, p. 341, B. J., XVI, 1905.	On unknown shrub	Ceylon.
A. (*Chr.*) *malleolus*, Green, p. 342, B. J., XVI, 1905.	On *Mimusops hexandra.*	Do.
A. (*Chr.*) *cistuloides*, Green, p. 342, B. J., XVI, 1905.	On cinnamon leaves	Do.
A. (*Chr.*) *quadriclavatus*, Green, p. 343, B. J., XVI, 1905.	On *Murraya exotica*.	Do.
A. (*Chr.*) *taprobanus*, Green, p. 344, B. J., XVI, 1905.	On *Phyllanthus myrtifolius.*	
A. (*Cryptophyllaspis*) *occultus*, Green, p. 56, C. of C., Pt. I, 1896, Pl. XI.	On *Grewia orientalis*	Pundaluoya, Ceylon.
A. (*Cry.*) *occultus* var *elongatus*, Green, p. 345, B. J., XV, 1905.	...	Ceylon.
A. (*Targionia*) *phyllanthi*, Green, p. 344, B. J., XVI, 1905.	On *Phyllanthus* .	Do.
A. panici, Ruth., p. 113, B. J., XXIV, 1915.	On *Panicum* . .	Peradeniya, Ceylon.

Odonaspis, Ckll.

O. (*Aspidiotus*) *inusitatus*, Green, p. 66, C. of C., Pt. I, 1896, Pl. XVI. *O.* (*Aspidiotus*) *inusitatus*, Green, p. 71, B. J., XIII, 1900.	On bamboo . .	Kelani Valley, Ceylon.
O. (*Chionaspis*) *simplex*, Green, p. 160, C. of C., Pt. II, 1899, Pl. LVII.	Do.	Pundaluoya, Ceylon.

O. (*Chionaspis*) *simplex*, Ramakrishna Ayyar, p. 22, Pusa Bull., 87, 1919.	On bamboo . .	Coimbatore, South India.
O. canaliculatus, Green, p. 72, B. J., XIII, 1900.	Do. . .	Pundaluoya, Ceylon
O. penicillata, Green, p. 346, B. J., XVI, 1907.	Do. . .	Ceylon.
O. penicillata, Ramakrishna Ayyar, p. 22, Pusa Bull., 87, 1919.	Do. . .	Coimbatore, South India.

Leucaspis, Targ.

L. cockerelli, de Charmoy (1899), Green, p. 354, B. J., XVI, 1915.	On *Dracæna* and *Pritchardia*.	Peradeniya (Ceylon).
L. limoniæ, Ruth., p. 117, B. J., XXIV, 1915.	On *Limonia alata* .	Do.
L. indica, Marl., Green, p. 449, Rec. Ind. Mus., XVI, 1919.	On mango . .	Poona (Bombay).
L. indicæ-orientalis, Lind., p. 127, Zt. F. Wiss. insektenbiol, VI(4), 1911.	On *Pinus khasya* .	India.
L. japonica, Ckll., Green, p. 449, Rec. Ind. Mus., XVI, 1919.	On *Ficus religiosa* .	Calcutta.
L. salicis, Green, p. 449, Rec. Ind. Mus., XVI, 1919.	On *Salix* sp. . .	Baluchistan.

Aonidiella, Berl. and Leon.

A. pothi, Ruth., p. 262, Bull. Ent. Res., V, 1915.	On *Pothos scandens*.	Peradeniya, Ceylon.

Aonidia, Targ.

A. corniger, Green, (*Greeniella corniger*, Ckll.), p. 69, C. of C., Pt. I, 1896, Pl. XVII.	On *Psychotria* and *Litsea*.	Pundaluoya (Ceylon).
A. bullata, Green, p. 72, C. of C., Pt. I, 1896, Pl. XVIII and p. 73, B. J., XIII, 1900.	On *Nothopegia colebrookiana*.	Do.
A. loranthi, Green, p. 74, C. of C., Pt. I, 1896, Pl. XIX.	On *Loranthus* sp. .	Do.
A. obscura, Green, p. 74, C. of C., Pt. I, 1896, Pl. XIX.	On *Loranthus* .	Pundaluoya, Ceylon.
A. perplexa, Green, p. 252, B. J., XIII, 1900.	On *Mesua ferrea* .	Peradeniya, Ceylon.
A. planchonoides, Green, p. 252, B. J., XIII, 1900.	On *Ficus* . .	Do.
A. spatulata, Green, p. 348, B. J., XVI, 1905.	On *Psychotria* .	Do.
A. mesuæ, Green, p. 348, B. J., XVI, 1905.	On *Mesua* . .	Peradeniya, Ceylon.

A. echinata, Green, p. 347, B. J. XVI, 1905.	On *Hemicyclia sepiaria*.	Anuradhapura, Ceylon.
A. pusilla, Green, p. 347, B. J., XVI, 1905.	On *Carissa spinarum*	Ceylon.
A. crenulata, Green, p. 348, B. J., XVI, 1905.	On *Memecylon* .	Do.
A. crenulata, Green, p. 441, Rec. Ind. Mus., XVI. 1919.	On *Vatica lanceifolia*	Assam.
A distinctissima, Newst., Green, p. 35, Pusa Mem., II, 1908.	On *Nerium oleander*.	Baluchistan.
A. dentata, Lind. (1911), Green, p. 441, Rec. Ind. Mus., XVI, 1919.	On *Walsura piscidia*	Kumlekum Hill (North India).
A. spinosissima, Lind. (1911), Green, p. 441, Rec. Ind. Mus., XVI, 1919.	On *Mimusops hexandra*.	Central India.
A. targioniopsis, Lind. (1911), Green, p. 441, Rec. Ind. Mus.; XVI, 1919.	On *Miliusa velutina*.	Burma.
A. viridis, Lind. (1911), Ramakrishna Ayyar, p. 22, Pusa Bull., 87, 1919.	On *Aglaia* . .	Travancore (South India).
A. indica, Green, p. 440, Rec. Ind. Mus., XVI, 1919.	On unknown plant .	Calcutta.
A. ferreæ, Ruth., p. 265, Bull. Ent. Res., V, 1915.	On *Mesua ferrea* .	Peradeniya, Ceylon.
A. tentaculata, Green, p. 440, Rec. Ind. Mus., XVI, 1919. *A. tentaculata*, Ramakrishna Ayyar, p. 22, Pusa Bull., 87, 1919.	On *Vateria indica* .	Quilon (South India).

Pseudaonidia, Ckll.

P. oreodoxæ, Ruther., p. 260, Bull. Ent. Res., V, 1915.	On *Oreodoxa* . .	Peradeniya, Ceylon.
P. irrepta, Ruth., p. 261, Bull. Ent. Res., V, 1915.	On unknown plant .	Do.
P. fossor, Ruth., p. 193, Bull. Ent. Res., V, 1915.		Ceylon.

Gymnaspis, Newstead.

G. spinomarginata, Green, p. 348, B. J., XVI, 1905.	On *Mesua ferrea* .	Peradeniya, Ceylon.
G. ficus, Green, p. 441, Rec. Ind. Mus., XVI, 1919. *G. ficus*, Ramakrishna Ayyar, p. 22, Pusa Bull., 87, 1919.	On *Ficus retusa* .	Kollegal, South India.
G. ramakrishnæ, Green, p. 442, Rec. Ind. Mus., XVI, 1919. *G. ramakrishnæ*, Rumakrishna Ayyar p. 22, Pusa Bull., 87, 1919.	On *Hemigyrosa scanescens*.	Courtallum, South India.

Lepidosaphis, Shimar.

L. beckii, Newm., Green, p. 78, C. of C., Pt. I, 1896, Pl. XX.	On *Citrus and Toddalia*.	Ceylon.
L. beckii, Newm., Ramakrishna Ayyar, p. 23, Pusa Bull., 87, 1919.	On pepper . .	Travancore, South India.
L. cocculi, Green, p. 81, C. of C., Pt. I, 1896, Pl. XXI.	On *Cocculus macrocarpus*.	Kandy, Ceylon.
L. gloveri, Pckd., Green, p. 83, C. of C., Pt. I, 1896, Pl. XXII.	On orange . .	Do.
L. pallida, Green, p. 85, C. of C., Pt. I, 1896, Pl. XXIII.	On unknown plants .	Do.
L. pallida, Ramakrishna Ayyar, p. 24, Pusa Bull., 87, 1919.	On guava . .	Godavari District.
L. lasianthi, Green, p. 253, B. J., XIII, 1900.	On *Lasianthus* and croton.	Ceylon.
L. fasciata, Green, p. 31, Jour. Eco. Biol., VI, 1911.	On rubber . .	Do.
L. erythrinæ, Ruther., p. 264, Bull. Ent. Res., V, 1915.	On *Erythrina* bark .	Peradeniya, Ceylon.
L. ambigua, Ruther., p. 264, Bull. Ent. Res., V, 1915.	On *Mesua ferrea* .	Do.
L. vandæ, Ruther., p. 116, B. J., XXIV, 1915.	On *Vanda spathulata*	Do.
L. piperis, Green, p. 34, Pusa Mem., II, 1908. *L. piperis*, Ramakrishna Ayyar, p. 22, Pusa Bull., 87, 1919.	On *Piper nigrum* .	Malabar, South India.
L. travancoriensis, Lind. (1911), Green, p. 446, Rec. Ind. Mus., XVI, 1919.	On *Aglaia minutiflora*.	Travancore.
L. auriculatus, Green, p. 446, Rec. Ind. Mus., XVI, 1919.	On croton . .	Calcutta.
L. retrusus, Green, p. 446, Rec. Ind. Mus., XVI, 1919.	On *Litsea whitiana* .	Nilgiris (8,000 feet) (South India).
L. retrusus, Ramakrishna Ayyar, p. 24, Pusa Bull., 87, 1919.	...	...
L. meliæ, Green, p. 445, Rec. Ind. Mus., XVI, 1919. *L. meliæ*, Ramakrishna Ayyar, p. 24, Pusa Bull., 87, 1919.	On *Melia* . .	Coimbatore, South India.

Ischnaspis, Dougl.

L. spathulata, Lind., p. 127, Zt. F. Wiss. inseketenbiol, VII(4), 1911.	On *Vatica obscura* .	W. Palukonda, Jumpalai (South India).

Parlatoria, Targ.

P. mytilaspi formis, Green, p. 164, C. of C., Pt. II, 1899, Pl. LVIII.	On *Psychotria*. .	Pundaluoya, Ceylon.

P. cingala, Green, p. 166, C. of C., Pt. II, 1899, Pl. LX.	On *Flacourtia* and *Scolpia*.	Pundaluoya, Ceylon.
P. aonidiformis, Green, p. 168, C. of C., Pt. II, 1899, Pl. LX.	On *Nothopegia colebrookiana*.	Do.
P. proteus, Curt., Green, p. 349, B. J., XVI, 1905.	On *Cymbidium bicolor*.	Kandy, Ceylon.
P. proteus, Curt., Ramakrishna Ayyar, p. 24, Pusa Bull., 87, 1919.	On *Vanda* and *Bellatulum*.	Bangalore, South India.
P. proteus var. *phyllanthi*, Green, p. 350. B. J., XVI, 1905.	On *Phyllanthus* .	Peradeniya, Ceylon.
P. proteus var. *mytilaspiformis*, Green, p. 35, Pusa Mem., II, 1908.	On *Cycas* . .	Bombay.
P. (Websteriella) atlantiæ, Green, p. 350, B. J., XVI, 1905.	On *Atlantia ceylonica*	Haragama, Ceylon.
Noted also on *Miliusa indica*, Courtallum (South India) by Lindinger.		
P. pseudaspidiotus, Lind., p. 131, Insekten Borse, XXII (33), 1905.	On *Vanda* . .	India.
P. pergandii, Comst., Ramakrishna Ayyar, p. 26, Pusa Bull., 87, 1919.	On croton . .	Peria Pass, Malabar, (South India).
P. pergandii, Green, p. 441, Rec. Ind. Mus., XVI, 1919.	On *Garcinia* . .	Singbhum (Bengal).
P. calianthina, Berl. and Leon., Ramakrishna Ayyar, p. 26, Pusa Bull., 87, 1919.	On *Nerium oleander*	Madras.
P. calianthina, Green, p. 445, Rec. Ind. Mus., XVI, 1919.	On Mango (Rajputana), on *Michelia* (Bombay).	
P. zizyphus, Luc., Green, p. 102, I. M. N., V(3), 1903.	On *Citrus* . .	Calcutta.
P. zizyphus, Luc., Ramakrishna Ayyar, p, 26, Pusa Bull., 87, 1919.	On *Citrus* . .	Coimbatore, South India.
P. artocarpi, Green, p. 442, Rec. Ind. Mus., XVI, 1919.	On jak . .	Periaghat, Malabar
P. artocarpi, Ramakrishna Ayyar, p. 26, Pusa Bull., 87, 1919.		(South India).
P (Websteriella) papillosa, Green, p. 443, Rec. Ind. Mus., XVI, 1919.	On jak . .	Palghat, South India.
P. (Websteriella) papillosa, Ramakrishna Ayyar, p. 26, Pusa Bull., 87, 1919.		
P. vateriæ, Green, p. 444, Rec. Ind. Mus., XVI, 1919.	On *Vateria indica* .	Quilon, South India.
P. vateriæ, Ramakrishna Ayyar, p. 26, Pusa Bull., 87, 1919.		
P. mangiferæ, Marl., Ramakrishna Ayyar, p. 27, Pusa Bull., 87, 1919.	On palmyra . .	Godavari, South India.
P. orientalis, Newst., Ramakrishna Ayyar, p. 24, Pusa Bull., 87, 1919.	On wild plant .	Coimbatore, South India.

P. camelliæ, Comst.	On *Melia*	Coimbatore, South India.
P. cristifera, Green (MS.)	On *Citrus*	Maddur, Mysore (South India).

Cryptoparlatorea, Lind.

C. parlatoreoides, Lind., p 89, Zt. F. Wiss. insektbiol, VII(3), 1911.	On *Xanthophyllum flavescens*.	India.

45.—A LIST OF PARASITIC HYMENOPTERA OF ECONOMIC IMPORTANCE FROM SOUTH INDIA.

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Since submitting my first list of economic parasites at the last meeting in 1919 (*vide* paper No. 69, pp. 931-936 of the *Report of the 3rd Entomological Meeting*), I have been able to gather further information and get further material worked out on the subject, and the following supplementary list is added to form a more or less complete and connected record of these useful insects so far as at present known. It is hoped it may be of use to those interested in this aspect of Entomology.

No.	Parasite.	Family or Sub-family.	Host.	Family or Sub-family.	Locality.
1	*Telenomus colemani*, Craw.	Proctotrypidæ	Eggs of *Dolycoris indicus*.	Pentatomidæ .	Mysore.
2	*Hadronotus fulviventris*	Do. .	Eggs of *Clavigralla gibbosa*.	Coreidæ . .	Bangalore.
3	*Anastatus colemani* .	Encyrtidæ .	Eggs of *Degonetus serratus*.	Pentatomidæ .	Do.
4	*Pleurotropis foveolatus*, Craw.	Eulophidæ .	Larva of *Epilachna*.	Coccinellidæ .	Do.
5	*Tetrastichus colemani*, Craw.	Do. .	Larva of *Aspidomorpha miliaris*.	Chrysomelidæ .	Do.
6	*Tetrastichus ophiusæ*, Craw.	Do. .	Larva of *Achæa janata*, Linn.	Noctuidæ .	Mysore.
7	*Euplectrus nyctemeræ*, Craw.	Do. .	Larva of *Nyctemera lacticinia*.	Hypsidæ .	Bangalore.
8	*Bruchocida orientalis*, Craw.	Eupelmidæ .	Larva of *Bruchus chinensis*.	Bruchidæ .	Do.
9	*Bruchobius colemani*, Craw.	Pteromalidæ .	Do. .	Do. .	Do.
10	*Apanteles prodeniæ*, Vier.	Braconidæ .	Larva of *Prodenia litura*.	Noctuidæ .	Do.
11	*A. taragamæ*, Vier. .	Do. .	Larva of *Taragama dorsalis*.	Lasiocampidæ	Do.
12	*Aphidius colemani*, Vier.	Do. .	Aphis on tobacco	Aphididæ .	Do.
13	*Meteorus arctiicida*, Vier.	Do. .	Larva of . .	Arctiadæ .	Mysore.
14	*Protopanteles colemani*, Vier.	Do. .	Larva of *Orgyia postica*.	Lymantriadæ .	Do.
15	*P. creatonoti*, Vier. .	Do. .	*Creatonotus albistriga*.	Arctiadæ .	Do.
16	*P. papilionis*, Vier. .	Do. .	*Papilio demoleus* and *P. polytes*.	Papilionidæ .	Do.

No.	Parasite.	Family or Sub-family.	Host.	Family or Sub-family.	Locality.
17	*P. stauropi*, Vier.	Braconidæ	*Stauropus alternus*	Notodontidæ	Bangalore.
18	*Microtoridea lissonota*, Vier.	Ichneumonidæ.	*Achæa janata*	Noctuidæ.	Mysore.
19	*Neopimploides sylepta*, Vier.	Do.	*Sylepta derogata*	Pyralidæ	Do.
20	*Pristomerus euzopheræ*, Vier.	Do.	*Euzophera perticella.*	Do.	Bangalore.
21	*Zamesochorus orientalis*, Vier.	Do.	*Achæa janata*	Noctuidæ	Mysore.
22	*Asobara orientalis*, Vier.	Alysiidæ.	Fruit fly	Trypetidæ	India (Compere Coll).
23	*Diachasmimorpha comperii*, Vier.	Braconidæ	Do.	Do.	Do.
24	*Apanteles phycodis*, Vier.	Do.	*Phycodes radiata*	Glyphipterygidæ	Bangalore.
25	*A. plusiæ*, Vier.	Do.	*Plusia peponis*	Noctuidæ	Do.
26	*Euagathis cryptophlebiæ*, Vier.	Do.	*Argyroploce illepida.*	Eucosmidæ	Mysore.
27	*Mesochorus plusiæphilus*, Vier.	Ichneumonidæ (a hyperparasite? on No. 25).	*Plusia peponis*	Noctuidæ	Bangalore.
28	*Bruchophagus mellipes*, Gah.	Eurytomidæ	On *Dhaincha* pod.	..	Coimbatore.
29	*Eurytoma parasæ*	Do.	On *Parasa lepida* and *Thosea* sp.	Limacodidæ	Do.
30	*Eurytoma denticoxa*, Gah.	Do.	From stored Maize seeds.	..	Do.
31	*Eurytoma dentipectus*, Gah.	Do.	On gingelly gall fly.	Cecidomyiadæ	Do.
32	*Eurytoma setitibia*, Gah.	Do.	From galls on *Cordia myxa.*	..	Do.
33	*Eurytoma hindupurensis*, Gah.	Do.	..	..	Hindupur.
34	*Stomoceras ayyari*, Gah.	Chalcididæ	On *Parasa lepida.*	Limacodidæ	Coimbatore.
35	*Chalcis argentifrons*, Ash.	Do.	On Lasiocampid larva.	Lasiocampidæ	Do.
36	*Aphycus fuscidorsum*, Gah.	Encyrtidæ	On *Ceroplastodes cajani.*	Coccidæ	Do.
37	*Anicetus ceylonensis*, How.	Do.	Do.	Do.	Do.
38	*Paracopidosomopsis javæ*, Gir.	Do.	On *Plusia signata*	Noctuidæ	Do.
39	*Eucomys lecaniorum*, Mayr.	Do.	On *Lecanium nigrum.*	Coccidæ	Do.
40	*Eupteromalus parnaræ*, Gah.	Pteromalidæ	On *Parnara mathias.*	Hesperiadæ	Nellore.
41	*Meraporus vandinei*, Tuck.	Do.	On *Sitodrepa*	Ptinidæ	Madras.
42	*Iphiaulax* sp.	Braconidæ	*Chilo simplex*	Pyralidæ	Coimbatore, Kurnul.
43	*Merionotus* sp.	Do.	Do.	Do.	Do.
44	*Microplitis* sp.	Do.	*Achæa janata*	Noctuidæ	South India.

No.	Parasite.	Family or Sub-family.	Host.	Family or Sub-family.	Locality.
45	*Meteorus* sp.	Braconidæ	*Cirphis* sp.	Noctuidæ	South Arcot.
46	*Phanerotoma* sp.	Do.	*Euzophera perticella.*	Pyralidæ	Coimbatore.
47	*Aleiodes* sp.	Do.	*Contheyla rotunda*	Limacodidæ	Malabar.
48	*Chelonus* sp.	Do.	*Spodoptera mauritia.*	Noctuidæ	Do.
49	*Chelonella* sp.	Do.	*Stomopteryx nerteria.*	Gelechiadæ	South Arcot.
50	*Microbracon* sp.	Do.	*Earias fabia*	Noctuidæ	Ramnad.
51	*Megalommum* sp.	Do.	*Pulvinaria maxima*	Coccidæ	Coimbatore.
52	*Elasmus indicus*	Elasmidæ	*Anomalococcus indicus* Gr.	Do.	Do.
53	*E. nephantidis* Roh.	Do.	*Nephantis serinopa*	Xyloryctidæ	Do.
54	*Pediobopsis locustivora* Roh.	Eulophidæ	Locustid eggs on *Cordia* leaf	Tettigoniadæ	Do.
55	*Pleurotropis epilachnæ*, Roh.	Do.	*Epilachna* sp.	Coccinellidæ	Do.
56	*Tetrastichus ayyari*, Roh.	Do.	*Chilo simplex*	Pyralidæ	Do.
57	*Tetrastichus nyemitawae*, Roh.	Do.	Cholam maggot	Anthomyiadæ	Do.
58	*Tetrastichus coimbatorensis*, Roh.	Do.	Cholam gall fly	Cecidomyiadæ	Do.
59	*Euryscotolinx coimbatorensis*, Roh.	Do.	*Cyphosticha cœrulea.*	Gracillariadæ	Do.
60	*Euplectrus euplexiæ* Roh.	Do.	*Perigea capensis*	Noctuidæ	Do.

In the above list Nos. 1 to 27 inclusive are South Indian species described by Crawford and Viereck in the *Proceedings of the United States of America National Museum*, Vol. 42 (1912-13), from material apparently forwarded to them by Dr. Coleman of Mysore. Those from Nos. 28 to 41 are species recently described by Mr. Gahan of U. S. A. Bureau of Entomology from material submitted from Coimbatore. The rest (42-51) are Braconids, the generic determinations alone of which were communicated to us very recently by H. L. Viereck to whom I had submitted a consignment of these and other Braconid parasites. Mr. Viereck writes that he is unable to work out the specific characters and has suggested that we might describe them, adding at the same time that most of our forms are new. I have an idea of describing in course of time the more easily determinable species with the help of available literature on forms previously recorded from India. Nos. 52-60 are Chalcidoid wasps very recently described by Rohwer of the U. S. A. National Museum (published in *Annals and Magazine of Natural History*, Vol. VII, January 1921, p. 123) from a consignment of para-

sitic Hymenoptera submitted to Dr. L. O. Howard from Coimbatore a couple of years ago.

It is unnecessary to add that there still remains a considerable amount of unworked material which would appreciably add to the above list. But all the same, now that we have some at least of the more important forms identified and a beginning made, it may at least help us to work up from this small nucleus and get further information on these very interesting and extremely useful insects.

The scattered manner in which descriptions of these parasitic Hymenoptera and of many other insects described from India have appeared recently will give workers in these groups much trouble. Odd papers are always appearing in the *Annals and Magazine of Natural History* and the *Proceedings of the U. S. National Museum.* It is very desirable that descriptions of Indian species should appear in Indian publications. There is no difficulty in this respect so far as means for publication are concerned. Prof. Felt's paper on new Cecidomyiadæ was sent out here for publication as a Memoir of this Department. I think that all specialists to whom Indian material is submitted for determination should be asked to send their descriptions for publication in India as far as possible.

Is this principle accepted by Government ? The Forest Department do not do so in the case of those outside their own service. I think a resolution would be within the scope of this meeting.

The Chairman then proposed the following resolution, which was seconded by Mr. Beeson :

" This meeting considers it desirable that papers dealing with Indian insects sent out to specialists by Government Institutes in India should be published in India in either Departmental or other publications as far as possible, in order to render them fully accessible to entomological workers in India." (*This Resolution was carried unanimously.*)

I agree. The best way to get a publication widely known is to get well known specialists to publish in it. If this is done Indian literature must be noticed by the whole world.

Government publications are lavishly distributed ; our Entomological publications go all over the world.

46.—REPORT OF THE CATALOGUE COMMITTEE.

The following orders have been catalogued :—

Orthoptera, Neuroptera, Strepsiptera, Microlepidoptera, Hemiptera, Homoptera.

Also the following families in other orders :—

Diptera.—Culicidæ, Tabanidæ, Dolichopodidæ, Muscidæ.

Coleoptera.—Scolytidæ, Platypodidæ, Bostrychidæ.

It is proposed to proceed in the near future with the issue of parts of the catalogue on :—

Culicidæ, Microlepidoptera, Bostrychidæ, Platypodidæ, Scolytidæ, Acrididæ, Acrydidæ, Strationyiadæ.

We hope to publish the Catalogue in parts which will necessarily vary with the size of the group treated in each part, but ordinarily each part will probably consist of 24 pages as a minimum.

Supplements might be issued in the same form as the *Zoological Record*.

This is already done in my annual report for the Board of Scientific Advice.

I have a list of Indian Staphylinidæ up to date for my own use comprising about 1,500 species but of course many more species remain to be described. Would the Committee care to publish it ?

If it is ready we shall be very glad to take it. We hope to keep these lists up to date.

In fact we hope they will get out of date quickly. As regards my promised catalogue of Passalidæ, I can do this very quickly when required.

temperature, or some gustatory, tactile, or visual perception, will be found in many other cases to supply the directive influence with regard to particular activities : their investigation will similarly lead to results which will enlarge our powers.

The investigation of these " susceptibilities " or" tropic responses," and the practical application of the results will entail in some cases a certain amount of difficulty, but the difficulty is more on the chemical than on the entomological side. I consider it to be extremely probable, for instance, that many agricultural insect pests find their food plants entirely or almost entirely by the smell of the whole plant or of some particular part of it such as the fruit. It will often be necessary to appeal to the chemist or the plant-physiologist for information as to the substances responsible for the attraction in such cases, but when a knowledge of these substances is obtained it will constitute an important addition to the armoury of the economic entomologist. One or two of the more obvious ways in which it might be possible to utilize it occur at once to one's mind ; it might be practicable to use the directing odoriferous substance as a trap for the insect, to enhance the attractiveness of a trap-crop, to neutralize the smell or taste of the plant by special traps or doctored manures or to " breed in " a different odour. It is allowable to suppose that in many plants the chemical characters on which their smell and taste depend may be susceptible to Mendelian manipulation in the same way as are those which determine certain other qualities.

It will perhaps be remarked :—" This talk of investigation and so on is all very well, but surely there is nothing new in discovering that insects are guided by their senses : what else should they be guided by ? " The point on which depend such valuable possibilities is not that they are guided by their senses in a general way, as we ourselves are, but that their more important activities, such as egg-laying and feeding, may be so largely influenced by one or two particular sensations or stimuli that they may be practically regarded as mechanical responses thereto. By pouring mint-sauce over a pair of boots we should not delude any ordinary man into actually eating the boots under the impression that he was being actually offered roast lamb, but we can so delude some insects. So long as the mint-sauce is there the lamb is taken for granted.

A person in the hypnotic condition referred to in the simile given above has been rendered peculiarly susceptible to suggestion, and his actions may be dominated by one or two ideas to which all else is subservient. Particular sights, sounds, smells or tastes may be made the stimuli which shall evoke in him the strongest desire to perform certain

acts previously suggested to him by the operator as being appropriate under the circumstances.

In dealing with the application of this analogy to the case of insects, we may leave on one side the problem of defining precisely what corresponds to the "operator." Though naturally essential to a proper understanding of insect psychology, the answer to this question need not necessarily affect the matter as viewed from the practical standpoint. "Analogy," as has been safely remarked, "is not the same thing as homology," but taking the hypnotic idea as a working basis, the cardinal point is the limitation or specialization of the insect's receptivity to a few particular stimuli which will in very many cases be found to be quite narrowly defined. It is this limitation or narrowly defined specialization, still partly hypothetical but already ascertained definitely in a few instances, and indicated to my mind in very many others, which promise most from the practical point of view. The more narrowly defined the stimulus which regulates any particular activity of an insect, the less difficult it will be to take advantage of it or to neutralize its action. In this connection the experiment of Verschaffelt, who found that the larvæ of the common white butterfly, *Pieris brassicæ,* which ordinarily feed upon leaves of *Cruciferæ,* are swayed in their choice of food not by the fact of whether the food offered them is or is not a portion of a cruciferous plant, but simply by the presence or absence of a group of chemical compounds (the mustard oils), is of extreme interest, and is in a direct line of research likely to afford results of the highest economic importance.

Observations of my own on the influence of certain smells on male fruit flies have shown that *Chætodacus diversus* is most strongly attracted by any substance which contains iso-eugenol, while *Ch. zonatus* and *Ch. ferrugineus* can in the same way be controlled in their movements to a remarkable extent by the use of the allied substance methyl-eugenol. Whether these smells characterize the females of these species, or whether they are sign-posts leading to a particular plant or fruit, has not yet been definitely ascertained ; the value of the observation lies in the specific character of the reaction to particular compounds. An interesting sequence to the identification of these attractive compounds was the fact that by exposing eugenol, a substance closely allied to the two already mentioned, I discovered an entirely new species of fruit fly, which was thus enticed from out of the unknown by a calculated appeal to a hypothetical olfactory susceptibility.

Other flies have been found to respond in a more or less similar way to the smells of acetic, butyric and valeric acids. As these acids are

produced in the decaying or fermenting vegetable stuff in which the insects have been found to breed, all these smells probably represent "egg-laying" or "food" smells. The attraction of amyl alcohol for a small, and otherwise rarely seen, Chloropid fly may be of the same type, as is also the attraction of skatol for females of *Sarcophaga*. Flower haunting flies seem to be, as might be expected, comparatively unspecialized in their tastes, and some species, *e.g.*, *Rhyncomyia* and *Scatopse*, come to a variety of sweet smells. A small Ceratopogonine Chironomid is attracted in very large numbers by anethol and particularly by anisaldehyde, and to a small extent by a few other aldehydes; it is probable that we have here to do with an insect which is more or less specialized with regard to a particular plant. As both sexes are attracted it is not a case of mono-sexual smell. At the beginning of the cold weather I discovered that *Thrips* was strongly attracted by two aldehydes, cinnamylaldehyde and benzaldehyde.* These experiments I propose to continue when *Thrips* again becomes active in the warm weather, and the investigation may produce results of interest, since the different species seem to show different degrees of specialization in their choice of food plants, while some of them, such as the tea-*Thrips*, are pests of importance. Moreover there are three or four other substances, which to us have almost exactly the same odour as benzaldehyde, although their chemical composition is by no means the same: by experimenting with these substances it may be possible to decide how far the olfactory sense of *Thrips* resembles or exceeds our own in delicacy of discrimination, and whether or not the attractiveness depends upon the presence in the molecule of the particular group of atoms characteristic of the aldehydes. It is unusually difficult to decide the sex of a *Thrips*, but as all those examined seem probably to be females, it is likely that this is also a case of a food or egg-laying smell, and not a sexual guide.

With regard to sexual smells Dr. Coleman of Bangalore recently informed me that he had performed an experiment to test the attractiveness of a light trap for females of the destructive "Kumblihula" moths, *Amsacta albistriga*, as compared with the attraction of the pineapple odour (emitted by the curious caudal tufts) of one of the male moths. The result was decisively in favour of the male, whose charms resulted in the capture of nineteen females in one night. This direct application of a sexual smell is of very great interest: if investigation shows that the attractive substance is one which can be cheaply procured, (*e.g.*, a simple ester such as amyl acetate), we have at once a delightfully easy and efficient method of dealing with a serious pest.

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*Journ. Eco. Biol. IX. 1. (March 1914.)

Sexual susceptibilities are capable of being more widely exploited than is at present the case. Several years ago I was initiated into a method of horse stealing based upon a knowledge of these instincts, a demonstration leaving no doubt that it could be successfully applied in practice. In response to inquiries for assistance in dealing with the plague of mongooses in Mauritius, I recommended some time ago that the males should be trapped by devices which took advantage of their attraction to the smell emitted by a female during the period of oestrus. To anyone who had not paid particular attention to the matter my suggestions might have appeared a little far fetched and were probably not acted upon. There is in reality, however, no reason why such methods should not be perfectly practicable in many cases, for common observation shows that in the sexual instinct we are undoubtedly dealing with one of the most potent influences in nature.

Little has been done in the study of a sense physiology of those blood-sucking insects which transmit diseases, but with these no less than with agricultural pests the establishment of my theory of discrete determinants will result in a great strengthening of man's position, and an economy of much of the money and energy which is now expended, to obtain results which are often inadequate. Some experiments of mine on the factors which influence the biting of mosquitos showed that all bold-biting mosquitos, with the exception of *Culex fatigans*, would bite eagerly at a surface warmed to 35°-40° C., while they neglected blood or a cold surface. I believe it probable that mosquito-bite will ultimately be found to be induced by warmth *plus* another factor probably a smell. More recently Hindle and Merriman have succeeded in inducing ticks to feed on salt solution instead of blood, by amputating the small sense-organ (probably olfactory) in the front tarsi. A large number of accurate and interesting observations have been made upon *Glossina*, but little experimental work seems to have been directed to the elucidation of the particular stimuli which mainly affect it. As *Glossina* seems to be a fly with what Forel calls " a well-balanced mind," it may offer more difficulty than will be encountered in the case of other blood-sucking insects.

What I have said here may be summed up as follows :—Experiment has shown beyond the possibility of doubt that the relative importance of the different senses in insects is not the same as in ourselves. Moreover it appears probable that insect activities are often directed almost entirely by the presence or absence of one particular sensation or some very simple combination of sensations. These sensations or stimuli have been discovered in a few cases. If we are justified in assuming from these few instances that such a state of things is the rule among

insects, (as I believe we certainly are), then it will generally be possible to discover the particular stimuli which fit the specialized receptivities of any given insect, and which guide it in at least the three essentials of continued existence, feeding, pairing, and the choice of a suitable nidus for the young.

Economic Entomology relies at present very largely upon methods which are crude and wasteful of energy. This is noticeable even in countries where labour is far more expensive than in India, and where such methods as hand-picking are difficult to apply; while it would probably be impossible to find an entomologist or a sanitarian with experience of work in this country who would not readily admit that a very great amount of effort must ordinarily be expended in combating insects of agricultural or medical importance if any really satisfactory results are to be obtained. The fact that this large expenditure of time and money is at present necessary seems in great part to be due to our ignorance of what may be termed "applied insect psychology," our wide lack of knowledge of the influences or "considerations" which really have weight with an insect in determining the course of its main activities. For instance, Major James in a lecture on anti-*Stegomyia* operations in Ceylon, referring to the extreme difficulty in locating all breeding places, and the way in which, when all the breeding places that can be discovered have been sterilized, the insect finds and makes use of the most cryptically located collections of water, availing himself for the occasion of the usual lecturer's license, speaks of the mosquito as a clever and wily insect, and such it certainly appears to be if we look only at results. On the views expressed in this paper we should regard the result of a water-finding contest between a Municipality and a mosquito as a foregone conclusion. The insect, equipped as it certainly is with a keen susceptibility to the presence of moisture in the air, has thus the one thing really useful in looking for water; the mere man's wonderfully developed visual organs, enormously surpassing those of the mosquito in range and accuracy, are still obviously inefficient for detecting the presence of water enclosed in solid receptacles or otherwise screened from view.

The need of economic entomology in the present stage of its development seems to me to be above all the encouragement and prosecution of research along such lines as will lead to the introduction of those "constructive" methods of which the above are very simple examples. If we review the stock methods of combating insects we find that they are roughly as follows:—Insecticides, fumigation, bagging, and the destruction of breeding and hiding places, handpicking of eggs or larvæ, modifications of agricultural practice to secure strong plants, or to

produce a crop at a season unfavourable to the insect pest, the use of trap crops, the encouragement of parasites and predators, and the employment of light traps and attractive baits. The last four may be noted. Many phytophagous insects (but not all) will attack a weakly plant rather than a healthy one, but no degree of cultivation can prevent attack in the event of anything in the nature of a serious invasion; the use of trap crops is a valuable device on the right lines, but its employment is limited by agricultural conditions and lack of precisely that kind of knowledge which research in the directions I have suggested would supply. In attempting to increase the incidence of parasitism or predation upon a given species of insect we are plunged at once into a complex web of inter-relations that demand a great deal of patient and difficult work for their proper undersanding; between every parasite and its host there exists an equilibrium dependent upon the amount of food available for each, and while by artificial means we may shift this equilibrium temporarily in a given area, to shift it permanently demands constant watchfullness and a wide and efficient organization; light traps are effective for the capture of certain insects, but in spite of the excellent work done by Loeb and others the action of light on nocturnal insects is not yet understood, and the conditions which largely affect the practical utility of the method are still unknown: the same thing may be said of the use of attractive baits; these are still in the "treacle-and-beer" stage, and it is unnecesary to insist further that there exists here an opening for research of remarkable interest and great economic importance.

When we consider these methods as a whole, and think of the apparent multitudinous complexity of the web of insect life which covers the surface of the earth, our task of controlling the pattern of the web with such instruments must often seem discouraging in its magnitude. If we are right in regarding the majority of insects as being for practical purposes mere creatures of their environment, "somnambulists" swayed and controlled by invisible threads, subtle and delicate, but definite and discoverable, then, instead of beating at the elastic face of the web and striving to break the pattern by sheer weight and force, we may be able to get hold of the threads themselves and weave a pattern to our own liking.

[Mr. Howlett is now, alas, no more, and all he hoped to do remains undone. I am indebted to Mr. S. K. Sen of his Staff for the following notes on some of the lines of work which are being prosecuted in the attempt to solve some of the problems he outlined in the foregoing paper, which are given in the hope that some investigator with a bent towards this line of work may perhaps carry them on. For convenience

sake a list of the papers published by Mr. Howlett and his Assistants on this subject is appended.—Ronald A. Senior-White].

The lines of inquiry may be classified under the following heads :—

(1) *Specialized egg-laying habits.*—The factor or factors that determine insect oviposition, *i.e.*, whether the stimulus to which an insect responds in selecting a particular plant (or any other material) for oviposition is tactile or olfactory. The possibility of the stimulus operating through the organs of sight was not investigated. Whether the stimulus was of a thermal nature was also considered, but no convenient method of recording the temperature of plants could be devised. In this connection some interesting results were obtained with *Papilio demoleus*. It refused to oviposit on the thin green netting with which a lemon plant was kept covered, a fact which would seem to minimize the possibility of the olfactory factor coming into operation, but on one occasion it freely oviposited on both citron and *Duranta* leaves in a mixed bunch of the twigs of the two plants (uncovered) ; again, while it did not oviposit on *Duranta* leaves scented with extract of citron leaves, in one experiment it gave profuse layings on the leaves of an unscented *Duranta* plant, when this was the only plant with which it had been enclosed in the cage, a fact which would seem to complicate any theory that might be advanced with regard to the factors determining oviposition in these insects.

(2) *Specialized feeding habits, or the "educability" of insects.*—Attempts were made to extend Verschaffelt's experiment to caterpillars generally. Experiments were done with the Eri and Mulberry silkworms (*Attacus ricini* and *Bombyx mori*). The caterpillars refused to eat (*a*) a mixture of flour dough and finely minced leaves, (*b*) boiled leaves of their food plant, (*c*) flour dough treated with an extract of boiled leaves ; but they ate (*a*)dough, or certain other leaves, (*e.g.* rose and *Duranta*), sandwiched between leaves of their own food plant, (*b*) heavily punched leaves, with the punctured portions filled up with dough, (*c*) beaten bits of dough alternating with strips of leaves. There was also a notable change in the colour of the excrement of caterpillars fed on dough.

(3) *Energy Transformation.*—With a view to preparing a series of energy transformation curves, attempts were made to correlate the amount of food material taken by certain insects, (*e.g.*, *Eumenes*, *Sceliphron*), during their different stages of growth with their body weight. The weight of the excrement, as also the loss of moisture through evaporation, were taken into consideration so as to obtain, as far as possible, a series of correct " metabolism " curves.

(4) *Strength of chemical reactions of fruit flies.*—Reference has already been made (Scientific Reports, Pusa, 1919-20), to a series of experiments made in this connexion on the deterrent effects of varying quantities of certain chemicals mixed with a fixed quantity of methyl-eugenol, the substance which attracts certain species of *Chætodacus*. Attempts were also made to find out how far heat would ward them off from coming to methyl-eugenol, by exposing a quantity of mercury in an electrically heated basin over which was kept suspended cotton wool scented with methyl-eugenol, the bulb of the recording thermometer being immersed in the mercury. It was observed that however powerful the scent, the insects would hardly come to it if the mercury was sufficiently hot to injure them, which would seem to indicate the necessity of modifying our views that the scent has a stupefying effect on them.

HOWLETT, F. M. . . The influence of temperature upon the biting of mosquitos. (Parasitology, December 1910.)

——— . . The effect of oil of citronella on two species of *Dacus*. (Trans. Ent. Soc. London, October 1912.)

——— . . A trap for *Thrips*. (Journ. Eco. Entom., March 1914.)

——— . . Chemical reactions of fruit flies. (Bull Ent. Res., December 1915).

SEN, S. K. . . . Observations on the respiration of Culicidæ. (Ind. Journ. Med. Res., 1914.)

——— . . . A preliminary note on the role of blood in ovulation in Culicidæ. (Ind. Jour. Med. Res., 1917.)

——— . . . Beginnings in insect physiology and their economic significance. (Read before the Fifth Indian Science Congress, published in Agrc. Journ. India, October 1918.)

——— . . . A note on the effects of mercurous chloride on mosquito larvæ. (Read at Fourth Entl. Meeting.)

SHARMA, H. N. . . A preliminary note on the actions of acids, salts and alkalies on the development of Culicid eggs and larvæ. (Read at Fourth Entl. Meeting.)

SHARMA, H. N. AND SEN, S. K. Oviposition in Culicidæ. (Read at Fourth Entl. Meeting.)

In connection with this very interesting paper I should like to mention some of my observations on Anopheline mosquitos. When mosquitos are being dissected for sporozoits, they are generally not chloroformed but are slightly disabled by a few shocks, after which their legs are pulled out and the wings cut. They are then placed in normal saline solution for dissections, and then it is very frequently found that the mosquitos drink the saline solution vigorously. This leads us to presume that their legs have something to do with their taste (or perhaps thirst ?) and that as a result of the removal of the legs, the mosquitos have lost their sense of taste and perhaps also increased their thirst.

My observations were different to those of Mr. Iyengar, as regards the sucking of the saline solution by a mosquito after the removal of its legs. I made several species of mosquitos suck saline solution after the amputation of half the proboscis.

In 1914 we were trying some baits against grasshoppers and found that they came very readily to those flavoured with squashed mango. When doing this work again I did not use mangoes but terpenol, which a Chemist gave me when I asked him for something that smelt like a mango, and I found baits flavoured with this equally efficacious, at least three species coming readily.

Another observation I have made refers to the influence of bait on *Pachydiplosis oryzæ*. This species comes in very large numbers to the top of the shade over a 200 c. p. Wellington light used as a moth trap, but very few are found in the tray beneath the lamp. Other Cecidomyiadæ I have noticed in my bungalow attracted to hot air from the lamp and not to the light itself.

I have frequently noticed mosquitos attracted to the column of hot air about the radiator of a motor car. There is no question of light in this instance.

With regard to Mr. Howlett's point about the attraction of female *Amsacta albistriga,* in one year they came in very large numbers to the scent glands of living males in muslin bags, but in other years they did not do so. This may have been due to climatic conditions. We only tried one experiment in each place.

I was deputed to work at the sense response of *A. albistriga* at Palur in Madras, and dissected out the male genitalia to ascertain the nature of the sexual smell, but neither Mr. Howlett nor myself could determine it. We also tried a large number of scents, especially essential oils, but without result.

I should also like to suggest another line of work. The investigation of the optical properties of the solar spectrum in controlling the acti.

vities of Culicidæ, so far as flights are concerned (not the act of biting); Mr. Howlett tried various combinations of light without definite results.

After reading Mr. Howlett's paper on *Dacus* I took up this line of work, working with Dr. Imms at Manchester on houseflies. Our joint paper appeared in the *Annals of Applied Biology*. We found that their response to baits was greatest after a rainy day, so presumably humidity increases attraction.

There has been a practical application of Mr. Howlett's line of work in American Forests. Dr. Hopkinson, dealing with polyphagous bark beetles, found that there was a tendency for a species mainly feeding on one species of tree, to get its habits temporarily fixed, the polyphagous habit being temporarily recessive. This was applied in connection with epidemics in mixed stands. The percentage principle was applied to determine the species of tree chiefly attacked, and these alone were removed. Nothing has been done regarding the control of borers by the attractive principle in trees. Forestry has been practiced for a hundred years in Europe, but no Entomologist or Chemist knows what are the constituents of wood and bark immediately after the death of the tree. It is impossible for me to ask our Chemist for something that smells like a dying tree of any particular species. In the Himalayan turpentine distilleries no borers are attracted, and therefore the turpentine in the tree is not the attractive factor. The almost automatic response of insects to stimuli is brought out prominently by *sal* borer work. The pupal and immature imaginal periods are directly controlled by the percentage of moisture in the pupal chamber, which varies in the amount of moisture lost by the wood during the hot weather. A long "hot weather" results in delayed initial emergence and extended emergence period. Early rains mean an early initial date of emergence and short total period. By this we can regulate the storage of logs.

As an instance of delayed emergence owing to drying, I can instance a case of *Stromatium barbatum* which laid eggs in the insectary in 1917, and the larvæ are still living, though the normal life-cycle is about two years.

Stromatium belongs to a different class of dry heart-wood borers. Its normal cycle takes four years.

I found its normal cycle to be two years.

Mr. Beeson has used the phrase "almost automatic response to external conditions." This may be so in certain cases, but is not a general one. Four years ago I described to you the case of a mudcell building wasp which showed an appreciation of novel circumstances and exhibited intelligence rather than fixity of instinct.

In this matter of automatic response to fixed stimuli, I once noticed a potter wasp building in my bedroom. It gave up bringing in mud, and took to using the soap, but did not complete the cell with this, but returned to using mud. Why, I cannot say. The soap was regularly in use, and its moisture content presumably, therefore, constant.

48.—THE PEST ACT IN SOUTHERN INDIA.

By E. BALLARD, B.A., *Government Entomologist, Madras.*

[The Meeting went into Committee for this paper and the subsequent discussion.]

49.—AN INTERESTING EXAMPLE OF GYNANDROMORPHISM IN *MEGACHILE BICOLOR*, FB.

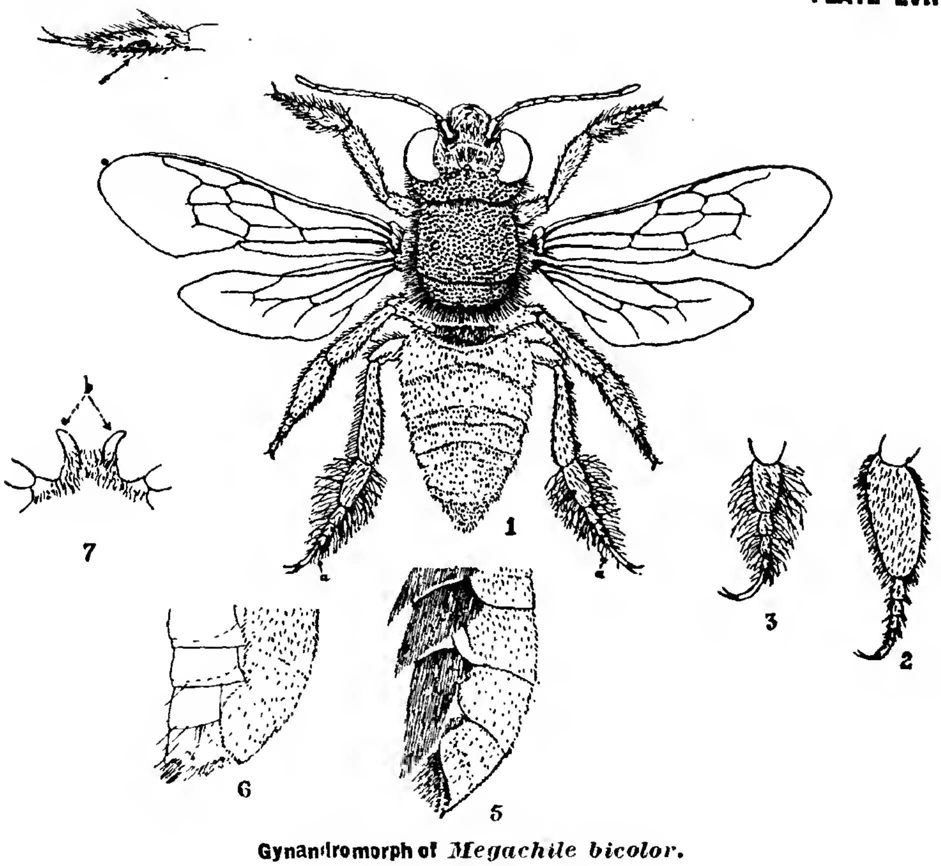
(Plate LVII.)

By G. R. DUTT, B.A., *Personal Assistant to the Imperial Entomologist.*

Megachile bicolor, Fb., is a widely distributed species throughout India. In the Pusa collection we possess examples of this species from as far as Peshawar and Rawalpindi in the North West, and Lower Burma in the East, from Pusa in the North and Trichinopoly in the South. Recently, while going through the species of the genus *Megachile* represented in our collection, my attention was arrested by an example of *Megachile bicolor*, Fb., which apparently looked like a female specimen, but possessed long lateral fringes of shining creamy-white hair on the posterior tarsi, a character which is peculiar to the males of this species. (Fig. 1.) At the same time it was noticed that the last tarsal joint of the posterior pair of legs was too long for a female specimen. (Fig. 1*a*). All the male examples of this species in the collection were examined, and in all cases, without any exception, it was found that the terminal tarsal joint of the posterior pair of legs was much longer than that of of the females. (Figs. 2 and 3). Again, all the males of this species have a dark brown spot on the inner side of the anterior tarsi and this spot was not absent from the tarsi of the specimen under reference. (Fig. 4). Further examination of this specimen revealed on the one hand an entire absence of the pollen brush from the ventral surface of the abdomen which is so essential a character for a female (Figs. 5 and 6) and on the other hand the presence of two large black spines on the anterior coxæ so characteristic of the males of this genus. (Fig. 7*b*). In short, it presented a peculiar blending of female and male characters in one specimen. The dorsal side possessed all the prominent characters of the female and the ventral side those of the male. The large size and the elongate, cordate abdomen without a notch on the apical segment, gave it an unmistakable look of a female. (Fig. 1).

EXPLANATION OF PLATE LVII.

Fig. 1. Gynandromorph of *Megachile bicolor*, Fb. ×4.
„ 2. Hind tarsus of *Megachile bicolor*, female ×6.
„ 3. „ „ „ male, ×6.
The terminal joint in the male is longer than that of the female.
„ 4. Underside of anterior tarsus of a male ; the arrow points to the characteristic mark on it. ×6.
„ 5. Underside of the abdomen of *Megachile bicolor* female, lateral view, ×6.
„ 6. Underside of the abdomen of Fig. 1 ; lateral view, ×6.
„ 7. Spines on anterior coxæ of Fig. 1 ; ×6.



Gynandromorph of *Megachile bicolor*.

(For explanation see text.)

50.—NOTES ON THE IMPERIAL ENTOMOLOGICAL CONFERENCE, LONDON, JUNE 1920.

By C. F. C. BEESON, M.A., *Forest Zoologist, Dehra Dun.*

Mr. Fletcher has asked me to say something about the Imperial Entomological Conference which was held in June, last year, in the rooms of the Linnean Society in London. In the report of this Conference, which, presumably, you have all seen, is given a list of the delegates sent by the various Self-governing Dominions, States and Colonies of the British Empire. There was in addition a very large attendance of British Entomologists, and others interested in plant pathology. Among those who had had experience of Indian conditions were present Professor Lefroy, Dr. Imms, Mr. Speyer, Mr. Green and Mr. Kunhi Kannan ; but for reasons already known to you, we had to deplore the absence of an entomologist, who has done so much for the advancement of entomology in India, and who is most fitted for the task of describing to the Conference the work we are doing and hope to do out here. I refer, of course, to our Chairman.

I received the information that I was to attend the Conference as the representative of the Government of India, only a few days before its commencement, and was given no further instructions than a few notes sent me by Mr. Fletcher. It will probably be of interest if I mention briefly the opinions expressed by the members of the Conference on the proposals emanating from India.

(1) Review of Applied Entomology. It was suggested by Messrs. Fletcher and Ballard and supported by myself, that the Review should contain a subject-index, in which the titles of abstracts are classified in broad groups such as Bionomics, Tropisms, Physiology and Morphology, Control methods, Crop Pests, Systematic work, etc., and also that certain additions should be made to the list of journals that are abstracted in the review. These proposals did not meet with universal support, mainly on the grounds that the scope of the Review appeared to be satisfactorily defined at present, and that the inclusion of physiological, morphological and systematic papers would increase the editorial work disproportionately to the value of the results. I gathered that the majority of entomologists present found it feasible to rely on their own efforts to supplement the Review for their own special requirements. It was however agreed that the form of the Review and its contents could safely be left to the discretion of the Director of the Bureau of

Entomology. The Bureau does not maintain a special subject-index to the literature abstracted, but the question of increasing the scope of the present annual index is receiving attention. Dr. Marshall will be very pleased to receive suggestions bearing on this question.

(2) A suggestion was made that literature should be available for loan. The Bureau has a store of spare copies and is prepared to send them out on loan or to arrange for the copying of abstracts.

(3) The question of appointing a Coccidologist on the staff of the Bureau was referred to a sub-committee, who found themselves unable to recommend the adoption of this proposal, as they could see no necessity for such an appointment. But they expressed the view that the Director should encourage members of his staff to give special attention to particular groups of insects, particularly to those for the identification of which no specialist is available. The possibility of putting this into practice of course depends on the size of the staff attached to the Bureau.

(4) A suggestion, supported by Mr. Ballard and Dr. Newstead, was brought forward to the effect that prompt identification of insects would be ensured or at least placed on a more satisfactory basis by the payment of fees for the work. Dr. Marshall pointed out that the principle of payment for identifications was already accepted, but it had been found impracticable to fix any definite scale for payment generally. It was decided that funds should be provided for payment to specialists for identification work on a more extended scale than at present.

(5) The question of the issue of the catalogue of plant pests was examined by a sub-committee consisting of Mr. C. P. Lounsbury and myself, in consultation with Dr. L. O. Howard. The compilation of this catalogue has been in progress since the initiation of the Bureau; its object is to present a brief summary of the information contained in the whole of the literature published prior to the appearance of the Review in 1913, and to provide lists of all the pests occurring in each of the British possessions. In view of the work that we are doing in India in this direction, as testified by the publications of the Agricultural, Medical and Forestry research centres, by the reports of these Entomological Meetings, and by the recently sanctioned issue of a catalogue of the literature on Indian insects, I advised that the pests of British India should be omitted from consideration by the Bureau. It was further recommended that American and Canadian literature should not be dealt with, as it is receiving attention from the United States of America Bureau of Entomology and the American Association of Economic Entomologists. The desirability of speeding-up the issue

of the lists of plant pests was emphasized, in view of the fact that the triennial indexes of the *Review* will ultimately cover the whole field comprised by the Catalogue of Plant Pests, but it was agreed that the provision of extra staff for this purpose was not justified.

(6) The financial position of the Bureau was considered by a Committee on which I also served. Dr. Marshall pointed out that in view of the post-war inflation of values the Bureau would not be able to carry on after April 1921, unless the funds at its disposal were considerably increased. I need not go into the details of the establishment and the estimates of the expenditure. The staff recommended is given in an appendix to the report; the expenditure estimated on a post-war basis amounts to £13,000; the increased amount is due almost entirely to revised salaries, and includes the provision of three new assistants' posts, one mainly for identification work and two for publication work. I understand that it is probable an Orthopterist will be appointed to the former.

The Conference was dismayed to learn that the activities of the Bureau might cease for want of funds and strongly recommended that the contributing Governments should be asked to increase their contributions so as to place the Bureau on a permanent basis. As regards our Oriental possessions, India was asked to raise its contribution from £500 to £1,000, Ceylon from £100 to £500, and the Federated Malay States from £100 to £750. I understand that every Government has agreed to contribute the sum suggested except Newfoundland, which has definitely refused, and Grenada, British Honduras and British India, which have not yet arrived at a decision.

The present moment appears to be an excellent opportunity to ascertain to what extent economic entomologists in India value the work of the Imperial Bureau of Entomology, and I trust that expresssions of opinion will be forthcoming that will justify the action I have taken in recommending to the Government of India that they should guarantee an annual contribution of £1,000. The value of the *Review of Applied Entomology* to us cannot be overstated. We have grown to rely on it to an extent that we shall sadly realise, if it's publication has to cease for lack of funds. Personally, I consider that the Review alone justifies an imperial contribution, and I believe I am right in saying that the Dominion of Canada has recognised this return as amply recompensing its donations, and that it does not look to the Bureau for assistance in other directions.

In conclusion I wish to refer briefly to the subject matter of the papers read at the Conference and the discussion that followed them

as they illustrate very strikingly the trend of modern thought in economic entomology.

There was general agreement that the special training of the economic entomologist should be based on a liberal education in pure science. A wide outlook is essential in the student. The extent to which his training in the field of pure science is practical must naturally vary, but it is of primary importance that he should be acquainted with the sources of information and should learn when to apply for information to other specialists and should be able to appreciate their points of view. A point of considerable interest was the almost unanimous agreement of economic biologists as to the necessity for a thorough training in the principles of agricultural science (or in horticulture, forestry, etc.). No economic entomologist who is not well acquainted with the cultural practices of the crop with which he deals can hope to devise practical methods for the control of its pests. Whether the emphasis be laid on the pure or the applied science in the entomologist's course of training, it must be remembered that it is the man who counts and not the method.

The days when the only weapons for dealing with plant diseases were the tracing out of the life-history and the destruction of the parasite at some part of its life-cycle, or the prevention of infection by the use of repellents, protective materials, etc., are rapidly disappearing. The discussions that followed the subjects of "Resistence of Plants to Insect Attacks," "Artificial versus Natural Control," and the general papers on insect pests, showed the aspects from which the question of pest control is now-a-days viewed. The impression I gained was that the study of the pest cannot be dissociated from that of the host, or from the external conditions governing both. The ecological and physiological outlooks are most necessary in the investigator who has to evolve lines of research, for it is becoming evident that permanent control of crop pests will be secured mainly by modified cultural rules; and that these will be the product of the team-work of experts in several branches of natural science.

We are very much obliged to Mr. Beeson for giving us this first-hand account, as the printed Report of this Conference is very brief. Regarding the value of the *Review of Applied Entomology* there can be no difference of opinion. The Imperial Bureau of Entomology has done most excellent work, both in abstraction and in research in Africa. The Bulletin has contained little Indian material as we have our own publications, perhaps too many of them. But in other countries such facilities do not exist. If the work published in the Bulletin had been scattered in odd reports of various African Administrations there would

have been a great deal of trouble to find out what had been done. Regarding the *Review*, I am sorry that the Bureau does not see its way to extending the scope of its abstracts to the other aspects of the science of interest to Economic Entomologists. I suggested that room might be provided for this and space saved by condensing reviews, especially of the papers appearing in the *Bulletin of Entomological Research* and of other papers which every serious worker must see. But these views were not accepted.

I entirely agree. Both in India and Africa I have found the Bureau of the greatest value. Whilst in Africa, had I not been able to publish in the *Bulletin*, my only other medium would have been as a supplement to the Government Gazette.

I quite agree. Dr. Marshall gives one identifications quickly.

Mr. Beeson wishes to put forward the following Resolution which I have much pleasure in seconding :—

"This meeting desires to record its appreciation of the work carried on by the Imperial Bureau of Entomology and particularly of the assistance obtained from the *Review of Applied Entomology*. It considers that this publication has in the past proved an ample recompense for the annual contribution of £500 made by the Government of India. It is of the opinion that, in view of the great expansion projected in entomological work in the future, a contribution of £1,000 per annum is fully justified."

[*Carried unanimously.*]

[*The Meeting then concluded with the usual votes of thanks.*]

List of Resolutions passed by the Fourth Entomological Meeting.

Resolution I. (Page 366).

" This Meeting considers it desirable that papers dealing with Indian insects sent out to Specialists by Government Institutes in India should be published in India in either Departmental or other publications as far as possible in order to render them fully accessible to entomological workers in India."

(Proposed by Mr. T. Bainbrigge Fletcher, Imperial Entomologist, seconded by Mr. C. Beeson, Forest Zoologist, and carried unanimously.)

Resolution II. (Page 387).

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All names of insects are indexed under both their generic and specific names, but page references are only given under the former.

All names *in italics* are treated as synonyms and should be looked up in the Index under the names given in Roman characters.

Names of plants are not indexed.

Names of Authors and titles of Papers are not indexed; for such reference is invited to pages vii-ix.

In the case of page-numbers followed by an asterisk (*), a figure of the insect named will be found opposite the page referred to.

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